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The Canadian Chemical Industry

by John Davis

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ROYAL COMMISSION ON CANADA'S ECONOMIC PROSPECTS

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MARCH, 1957

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PREFACE

THE purpose of this report is to provide factual information on the nature of the market for chemicals in Canada and to describe, in a general way, the changing structure and long-term outlook for the chemical industry in this country.

Although the technical literature contains a great deal of detailed information, and although numerous articles have been written about the history of Canada's chemical enterprises and the men behind them, few attempts have yet been made to discuss this subject in broad economic terms. By describing some of the far-reaching effects which chemistry as an all-pervasive science is likely to have on the nation's industrial structure, it is hoped that this document will encourage others to study and report in a general way on this expanding segment of the Canadian economy.

This report, which deals with the background, present structure and market prospects of the chemical industry in Canada, has been built around a series of six articles written previously for the Department of Trade and Commerce publication *Foreign Trade*. During the past 12 months the original text has been substantially revised and expanded to include a great deal of material which has been made available by industry and by government departments to this Commission and its staff. As in the case of the earlier articles, Mr. J. P. Lounsbury has assisted with the economic analysis, as well as helped to collect and present much of the statistical information which this report contains.

Numerous individuals have been consulted. All have given generously of their time and supplied advice without which the quality of this study would have suffered greatly. Mr. C. R. Graham, Director of Market Research for J. T. Donald and Company, prepared the initial draft of what now appears as Chapters 4 and 6. An "Industry Committee" was formed to advise on the more technical aspects of this subject.

I would like also to express my appreciation for the generous assistance which has been given by others, both in University circles and in Government, with a view to improving the factual and qualitative nature of this Report.

John Davis

Ottawa,
March, 1957.

SUMMARY

CHEMICALS are rightly regarded as one of the nation's "growth" industries. Along with one or two others — notably electronics — it has not only been breaking production records, but has also been influencing the rate of expansion in other and widely different areas of industrial activity. This it has been doing through an effective combination of technological and market research — research which has been carried out on an unprecedented scale, and which has encouraged both the use of chemicals and the adoption of chemical processes and techniques in other and related sectors of the economy.

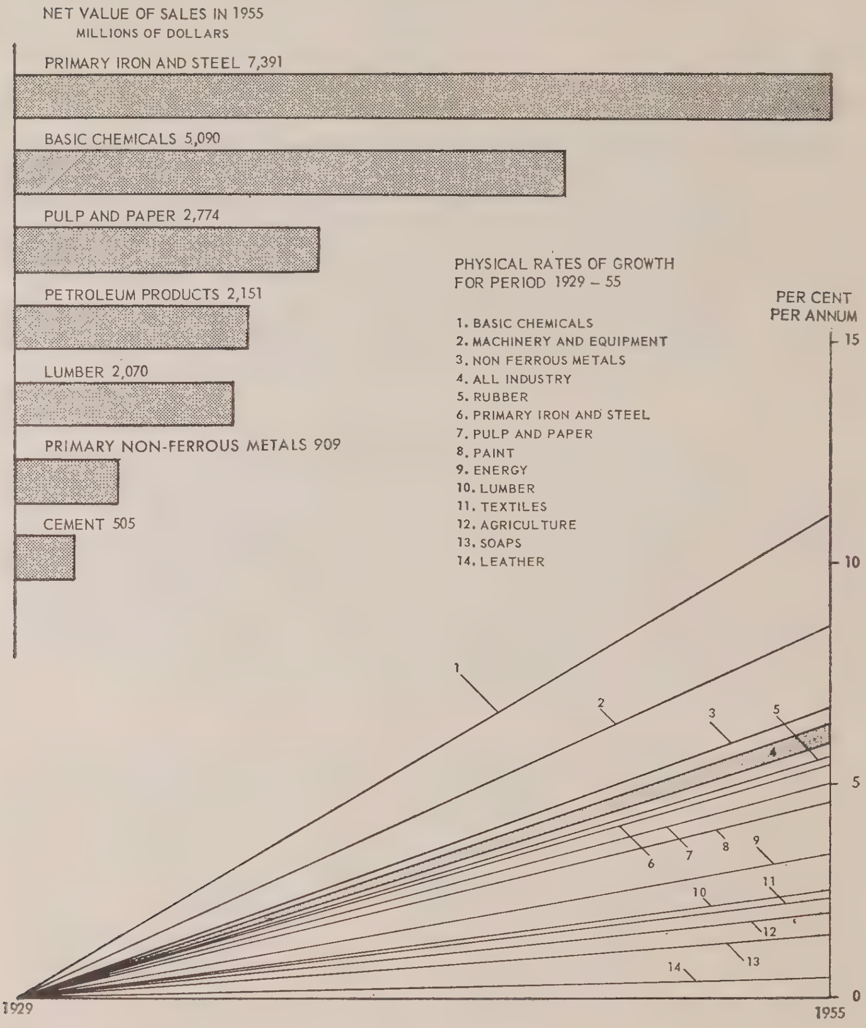
If chemistry as a science has made mankind less dependent upon a few naturally occurring substances, it has, at the same time, brought industries closer together. Major products, joint products and by-products are being exchanged in ever increasing volume. Continuous operations, lending themselves more to automation, are also fostering a greater degree of industrial integration. Under these circumstances the future of the chemical industry is hardly one which can be determined in isolation. Rather, its outlook and that of the mainstream of the Canadian economy are becoming ever more closely interwoven one with the other.

Growth is a popular word these days. Yet few industries have been expanding at the rate which chemicals have. On this continent the long-term rate of increase in sales has been around 9% per annum; that is to say, their volume has doubled every eight years. This appears to be all the more remarkable when it is pointed out that the rate for industry as a whole has been more in the order of 6%; doubling, that is, every 12 years. (See accompanying chart entitled Net Value of Sales and Growth Rates in Selected Industries in North America for a comparison of North American industrial growth rates over the period from 1929 to 1955.)

In Canada the market for chemicals and allied products is now in the order of $1.2 billion a year, or approximately 5% of the nation's total expenditure on goods and services. The chemical industry, by itself, provides year-round employment for more than 50,000 people. Also, the chemical industry in Canada reports an annual dollar value of sales comparable to that of the nation's petroleum refineries or to those plants producing electrical apparatus and supplies.

NET VALUE OF SALES AND GROWTH RATES IN SELECTED INDUSTRIES IN NORTH AMERICA

INDEX 1929 = 100



Factory-made chemicals have been essential to industry ever since developments leading to the mass production of textiles helped to initiate the industrial revolution over a century ago. Since that time chemicals have been used more and more extensively as processing agents for, and vital constituents of, many types of manufactured goods; as extractant and refining agents for the processing of natural resources; and more recently, as whole synthetic alternatives for naturally occurring products like rubber, the agricultural fibres and wood resins. Also, because of its increasing diversification, a growing proportion of the output of the chemical industry is being sold directly to end-users in the form of consumer and other fully manufactured goods.

For nearly 100 years Canada has had a chemical industry, an industry which even now is closely identified with resource development. Its earliest emphasis was on explosives for use in railway construction and in mining. Later, as electro-processing techniques began to be perfected, this country's chemical industry became more closely identified with the production of abrasives, light metals, acetylene, and bleaching agents for the treatment of pulp and paper. It gained further importance in the late 1920's with the large-scale production of fertilizers from smelter fumes. Subsequently, as natural gas and oil refinery by-products have become more readily available, production of such widely different products as artificial fibres and synthetic rubber has also got under way in this country.

As was the case with early developments in Great Britain and the United States, industrial chemicals based on local resources were the first to be produced. Being relatively heavy, they were difficult to transport. Hence it was logical that local requirements should be manufactured close at hand. For this reason a number of Canada's largest chemical factories are located alongside such resource processing industries as the smelting and refining of metals and the manufacture of chemical pulps.

Meanwhile, as organic chemistry began to assume importance in Europe, dye-stuffs and fine chemicals became major items of international trade. German producers, utilizing coal tar as their principal material, and protected by high tariffs, dominated this field until the end of World War I. Thereafter, protectionist measures invoked in many countries, and particularly in the United States, caused a much larger proportion of these high-unit value (and hence more readily transportable) chemicals to be produced in the countries where they were to be consumed. World War II provided a further stimulus to these autarchic tendencies. As a result, various countries, including Canada, now produce many of the larger volume chemicals which are required by the extractive and primary processing industries.

Lately, as a result of the much greater availability of crude oil and natural gas, a number of new plants have been built for the purpose of manufacturing petrochemical materials. These, in turn, are being used to expand syn-

thetic rubber, plastics and synthetic fibre production in this country. Nevertheless imports are continuing to be important both in value and volume terms. Many of Canada's organic chemical requirements are still purchased in the United States and, to a lesser extent, in Western Europe. Research elsewhere is continually turning up new chemical products and new uses for chemicals. A lack of markets (or markets large enough to support plants of minimum economic size) is given as another reason why the per capita production of chemicals in this country is still only about half of that reported for such highly industrialized countries as the United States.

There are important exceptions. Nitrogenous fertilizer materials, synthetic rubber, acetylene derivatives and rayon intermediates are being exported in large volume from Canadian plants which are every bit as large and as efficient to operate as those in the United States. Approximately one-fifth of the nation's total output of chemicals is produced in these plants and sold abroad. Yet the fact remains that many of the export markets which they serve were built up during and immediately after World War II when shortages were general and the chemical industry, particularly in continental Europe and Japan, was damaged and disorganized. Because of increasing competition from these quarters, and because of the continuing tendency towards national self-sufficiency in chemical production, it is doubtful whether Canada will be able to retain as large a share of the world's international trade in chemicals as she has acquired since 1939.

Forecasts described in greater detail in this report indicate that, by 1980, the market for chemicals in Canada may be approximately five times as great as that reported for 1955. Annual sales may, in other words, be in the vicinity of $6 billion. Producers in this country, it is thought, will serve a somewhat larger proportion of this demand than they do at present. Imports, consequently, are shown as falling from 25% of Canadian requirements to around 20% 25 years from now. Exports, at present accounting for about 20% of total Canadian chemical output, may also drop to between 10% and 15% of production during the quarter century under review.

1

GENERAL INTRODUCTION

FOUNDED, built and run essentially by men with scientific training the chemical industry employs techniques and equipment which are designed to serve a particular purpose. The majority of its processes are so overlaid with other activities that their nature is frequently unknown to the average consumer. Only a few of the names of its products are recognizable to the man on the street. Yet chemicals are exemplary of our age. Involving continuous operations and lending itself to automation the chemical industry is busily converting the commonest of raw material into an array of semi- and fully-manufactured products that grows ever more prodigious. Meanwhile, it is forging links of a corporate nature and through the medium of the market that are causing its workings to become ever more closely allied with those of the rest of the economy.

The science of industrial chemistry was little known a century ago. Even in 1900 most of the world's industries were based upon processes discovered largely by accident and practised with modifications for many generations.[1] Since then, however, the discoveries and services of chemists have been adopted by one industry after another. Today many more chemists are employed outside what one might call the chemical industry proper than are employed in it. What better indication could one have of the esteem in which chemistry is already held in the world of industry and business.

With the spreading of the scientific spirit and the initiation of systematic, scientific inquiries in the 18th and 19th centuries, a great body of chemical knowledge became available. Its application has ranged the whole gamut of industry, so that to talk of chemicals in industry is a far different thing than to talk of the chemical industry.

Chemistry in industry performs three main functions. First, in the physical change industries, it provides essential raw materials, methods of processing, and tests and controls for maintaining the quality of raw materials

[1] *e.g.*, the smelting of iron, the calcining of lime, the dyeing of cloth, the tanning of leather, the brewing of beer and the making of soap.

and products. Second, in the older chemical change industries, it has allowed the replacement of empirical processes by scientifically-proven methods that permit greater efficiency, closer quality control and the development of better products. Finally chemical science is the basis of the chemical industry itself.

The application of chemistry in other industries is well illustrated in Canada. The country's leading manufacturing industry, paper, uses chemical processes to produce all but its mechanical pulps. The production of pig iron and steel, and the smelting and refining of non-ferrous metals are primarily chemical in nature. More and more foods are made synthetically or receive chemical treatment. This is also true of clothing and other textiles. Petroleum refineries, with their cracking and reforming processes, are now run almost entirely by chemical engineers. Even the manufacture of cement and abrasives is based upon chemical change. Most of these activities, because of the history of their development, or because of the uniform nature of their end-products, are called separate industries. The chemical industry, as defined by the statisticians, is what is left over. It is a catch-all term partly based on convention and descriptive of the remaining chemical process industries; another reason why the chemical industry defies description in simple and readily understandable terms.

Already "chemicals" must be considered the leading industry in North America. Its rise has been precipitous and largely unnoticed. During most of the last 50 years this title was held by the automotive industry. Now even that has been overtaken. Eventually, chemicals may have to share the lead with that other loose federation of industries based upon electronic-nuclear sciences. But, in the next decade or so, even this portentous newcomer may not be able to match developments in the sphere of chemistry.

All-pervasive as it has been, the chemical revolution cannot be said to have affected all industries equally. Neither has it affected them all at the same time. This has been particularly true of Canada. Here, it first made hardrock mining possible, and then led on to the erection of pulp and paper mills and non-ferrous metal refineries. More recently, chemical developments laid the foundation for the rapidly expanding synthetic textile, plastics and plywood industries. Chemistry has also succeeded in revolutionizing oil refining, food processing, and the manufacture of such unlike things as drugs, paints and building materials. It has benefited agriculture and fishing, and it has hastened the exploitation of Canada's salt deposits as well as its uranium and titanium bearing ores. More than anything else, it has allowed Canadians to take advantage of their abundant hydro-electric power potential. So far only a few industries have suffered in consequence. Only wood distillation and some of the older woollen and cotton mills have been first neglected and then destroyed by the technological changes which this applied science has brought about.

Yet the chemical industry has done more than supply much needed ma-

terials or utilize otherwise surplus by-products. Frequently it has provided the scientific methods and the technical personnel without which development in other sectors of the economy would have occurred more slowly if, indeed, they would have occurred at all. For use in its own processes, it has also demanded from producers of building materials and manufacturers of machinery and equipment the next to impossible. In doing so it has helped to create still other industries, but industries of a basically different type; those concerned more with the physical sciences.

Chemistry has also been a strange new force influencing international trade. It is 100 years since the derivation of the first aniline dye from coal tar marked the beginning of synthetic organic chemistry. But the consequences of that discovery, which in a few years wiped out the ancient madder (red dye) industry of Southern Europe and the indigo plantations of India, was little more than an indication of things to come. As chemists slowly mastered their materials, the pace increased. First, by-product nitrogen and then synthetic ammonia began to undercut the natural monopoly of Chilean saltpetre, once the world's main source of fertilizers and explosives. Then synthetics began to replace natural fibres in the textile field, with severe repercussions on Japanese silk. The stimulus of war hastened along petrochemical developments such as the manufacture of synthetic rubber and man-made alcohol. These have, among other things, had the effect of reducing North American demands for natural rubber from Malayan and Indonesian sources, and for molasses from the West Indies.

Substitution of home-made synthetics for foreign natural products has been going on in lesser known ways as well. Insecticides, formerly obtained only from tropical flowers, are now made in chemical factories. Synthetic camphor has already largely displaced camphor from the Far East. Synthetic cinnamon and synthetic oil of wintergreen are retaining their wartime markets. Artificial musk now far exceeds the little musk deer of Tibet as a source for perfume bases and fixatives, and synthetic versions of gems such as sapphires, emeralds and rubies, or substitutes for diamonds, are troubling foreign producers of precious stones. What these, and similar developments in the field of nuclear chemistry, are likely to mean is hard to foretell, but one thing is already certain—they will curtail world trade in many natural products in years to come.

Here is a trend which free-trade economists have been reluctant to accept as inevitable—an inherent drive toward national and in some instances continental self-sufficiency. This trend is far from being spent, for only in the last 20 years has it reached unmistakably large proportions. But this chemical attrition of the older raw material empire goes on apace, and there can be little doubt that foreign policy makers will be wrestling with its after-effects for many years to come.

2

WORLD SETTING

WHILE the records show that chemical processing was not unknown to the early Greeks, Phoenicians and Chinese, the emergence of a genuine chemical industry did not come about until the 19th century. It was only then, in answer to the chemical needs which stemmed from the industrial revolution, that new methods began to be adopted. With the transformation of textile manufacturing from handicraft trades to large-scale production, an insatiable demand for dyes and bleaching compounds was created. England took an early lead in meeting this demand, her scientists perfecting methods for the production of soda ash, caustic soda, bleaching powder and sulphuric and nitric acids. Not only did this stimulate the diversification of Britain's industry, but it also enabled her to dominate, for a time, the world's markets for these and other heavy chemicals.

Toward the end of the 19th century, however, other industrial countries, particularly Germany and the United States, began to challenge England's leadership in this field. They were aided by important technological developments, such as the introduction in the 1860's of the round-about but more efficient Solvay process for the manufacture of soda ash, and in the 1880's by the perfection of the contact process for the manufacture of sulphuric acid. In this way they became progressively more independent of the British alkali industry, and at the same time were able to branch out into the manufacture of other inorganic acids and salts. The general trade policies of these different countries also probably influenced chemical developments on the national scale. While Britain at that time was a free trading country, most of the continental nations, and particularly Germany, had adopted highly protective measures that encouraged the growth of new industries.

More important than the contribution of all of these developments to the eventual eclipse of British chemical supremacy, was the discovery of the almost unlimited chemical potentialities of coal tar and its derivatives. Although this development originated in England, Germany quickly took the lead and by the outbreak of World War I was producing over three-quarters of the world's dye-stuffs as well as numerous other coal tar products. Al-

though the United States had by then become the world's leading chemical producer, due chiefly to its large volume of production of a relatively few heavy organic chemicals for the domestic market, American dye manufacturers supplied only a small proportion of that country's consumption. In those days, both they and their British counterparts were frequently little more than distributors of German manufactured products.

That country's predominance in modern "creative chemistry" stemmed mainly from three basic factors. First, Germany made an early start in adapting its educational system to the practical needs of modern scientific industry. Second, Germany was deficient in respect to such natural resources as high grade iron ore, non-ferrous metals and petroleum. Lacking colonies from which she could obtain these raw materials cheaply, Germany made up for this by virtually creating alternative sources of supply through industrial research. This unique and powerful tool was used to bring about the greater utilization of such domestic resources as coal, salt and potash.

The third factor was the ready recognition by both the state and by German businessmen of the importance of technology in industry. They brought into being the world's first well equipped laboratories, and assembled large, well trained research staffs. They also taught consuming industries how their chemical products could be used to advantage. The German government shaped its tariff and patent laws in such a way as to sponsor this programme of industrialization, and German industrialists were quick to use these advantages both at home and abroad to fortify their leadership in the field of industrial chemistry.

World War I awakened the Allied countries to the significance of German leadership in coal tar chemistry.[1] They saw in Germany whole industries converted almost overnight to the production of explosives and poison gas. They also saw the German chemical industry which had perfected synthetic ammonia production before the war's start, take nitrogen from the air and produce explosives without the use of Chilean nitrate. Lacking similar experience and research facilities, the Allies had to resort to makeshift arrangments. For a long time they leaned heavily on distant natural sources, and consequently it was many months before they could meet German ingenuity in the manufacture of the newer and more deadly munitions of war. Even then they usually did this by frantically adopting German processes and copying German plants as best they could.

These belated efforts, however, marked the beginning of independent modern organic chemical industries outside of Germany. In the years immediately after 1914, the United States, Great Britain, France and Canada made great progress in chemical technology, most signally perhaps in the manufacture of

[1]The by-product coke oven, perfected as an adjunct of the steel manufacture in the 1890's, not only became the backbone of the coal tar industry but became a major source of sulphate of ammonia fertilizers.

organic chemicals and synthetic nitrogen. They expanded enormously their capacity for recovering such basic coal tar crudes as toluol and phenol for use in the manufacture of explosives such as TNT and picric acid. They learned also to produce phenol synthetically and, with the help of sequestered German patents, to produce acetone, required in the manufacture of smokeless powder, cordite and "dope" for airplane wings.

After 1918, many countries, realizing the strategic need for independence from the German chemical industry, introduced high tariffs and import quotas, with the intention of encouraging greater domestic production. While this, together with the confiscation of enemy property and the free use of German-owned patents, bolstered the growth of organic chemical industries, particularly in the United States and Great Britain, it also served to limit international trade in chemicals. The net result has been that foreign markets since then have been largely closed to Canadian chemical producers. The situation which arose out of World War I has thus been a serious net disadvantage to the Canadian chemical industry—though war itself had greatly stimulated the growth of chemical manufacturing generally and had led somewhat belatedly to some diversification in Canada as well.

The interwar period, particularly the 1920's, was one of rationalization. Through stock transfers and other means, many small firms merged and others were absorbed by their larger competitors. It has been claimed that these moves were necessary in order to combat the giant international chemical trusts, especially those being organized in Germany. It is also alleged that the end of hostilities hastened the need for reorganization, particularly among manufacturers of explosives, who were faced with the task of utilizing excess manufacturing capacity created by the war, and of developing new products with peacetime applications.

Another reason seems to have been the relatively strong financial position of the larger corporations. Through their easier access to funds, they were usually able to construct larger plants and operate on a more efficient scale than their small single-line competitors. The bigger chemical concerns, therefore, increased their lead not only in this manner but also by being in a better position to carry out well co-ordinated research and product development programmes.

Amalgamation on a previously unheard-of scale resulted in vast organizations such as I.G. Farbenindustrie in Germany. This colossus included among its products not only fertilizers and dye-stuffs, but most other heavy and fine chemicals as well. The mid-twenties was also an era in which consolidation resulted in the formation of Imperial Chemical Industries in the United Kingdom; DuPont, Union Carbide, Allied Chemicals and American Cyanamid in the United States; and of Canadian Industries Limited in Canada.

Partly as a result of this process of corporate integration and partly due to mounting demands from the motor vehicle, oil refining, textile and paper

industries, the world's production of chemicals began to expand again after the period of stagnation which the industry had experienced at the end of World War I. Even following the stock market crash in 1929, it was able to consolidate many of its gains and to make inroads on other lines of manufacturing activity. Because of the chemical industry's diversified markets, and due to the fact that it was continually developing new products, chemical firms were able to weather the great depression much better than many others. They adopted what were then novel practices. Instead of cutting prices to uneconomic levels, they searched for new lines of production better suited to their customers' needs and they succeeded in finding substitutes for many natural products, much to the discomfort of what were even then regarded as the older and more established sectors of the economy.

A shift to the manufacture of consumer end-products was also beginning. Artificial fabrics, such as rayons, were becoming accepted, and synthetic fibres were being made in increasing volume. This was also the case with plastics and numerous other commodities normally sold at the wholesale or retail level, such as dry-cleaning fluids and anti-freeze.

But, as the 1930's wore on, preparation for war was again a factor, particularly in Germany and Japan. There government subsidies, direct and indirect, began to stimulate the production of synthetic rubber, aircraft and motor vehicle fuels, and light metals. This, together with aggressive selling policies on the part of a number of nationally sponsored combines, helped to cast Germany again in the role of the world's principal trader in chemical products, and to slow down the development of chemical industries elsewhere.

After 1939, war again fostered the expansion of plants making such products as fixed nitrogen explosives, medicinal chemicals and insecticides. The chemical industries in a sense did double duty, especially in North America. They supplied much of the managerial talent necessary to build and run government-owned munitions factories. With this help a billion-dollar synthetic rubber industry was created, and plants and processes were evolved for making the world's first atomic weapons. The magnitude of the chemical industry's contribution in this latter field of activity, overshadowed as it has been by the glamour of nuclear physics, has never been fully appreciated.

The war-born expansion programme in North America and the destruction wrought in Europe and Asia by World War II enabled the United States to assume a dominant role as far as chemicals were concerned. That country is now well established as the world's principal trader, particularly in such fields as medicinals and pharmaceuticals, chemical specialties, paints and pigments and numerous industrial chemicals.

The United Kingdom, despite the fact that it has had to make up for its wartime preoccupation with munitions manufacture, is now in second

place in world trade, followed by Germany and Canada. But in this field, Germany is well on its way to recovery. Damaged, disorganized and without markets and materials at the end of World War II, it has already attained a level of production which exceeds even that of the 1930's; and this despite the limitations and prohibitions which the Allies had imposed on some of its heavier industries. Canada, meanwhile, has come to play a prominent role as an exporter of nitrogenous and cyanamide fertilizers, synthetic rubber and plastics intermediates.

The remarkable expansion of the chemical industry, which has taken place over the past two decades, has been greatly assisted by the use of raw materials obtained from crude petroleum and/or natural gas. This largely explains the movement of United States chemical producers to the Gulf coast region and, in Canada, to the establishment of large chemical industries at Sarnia, Montreal and Edmonton.

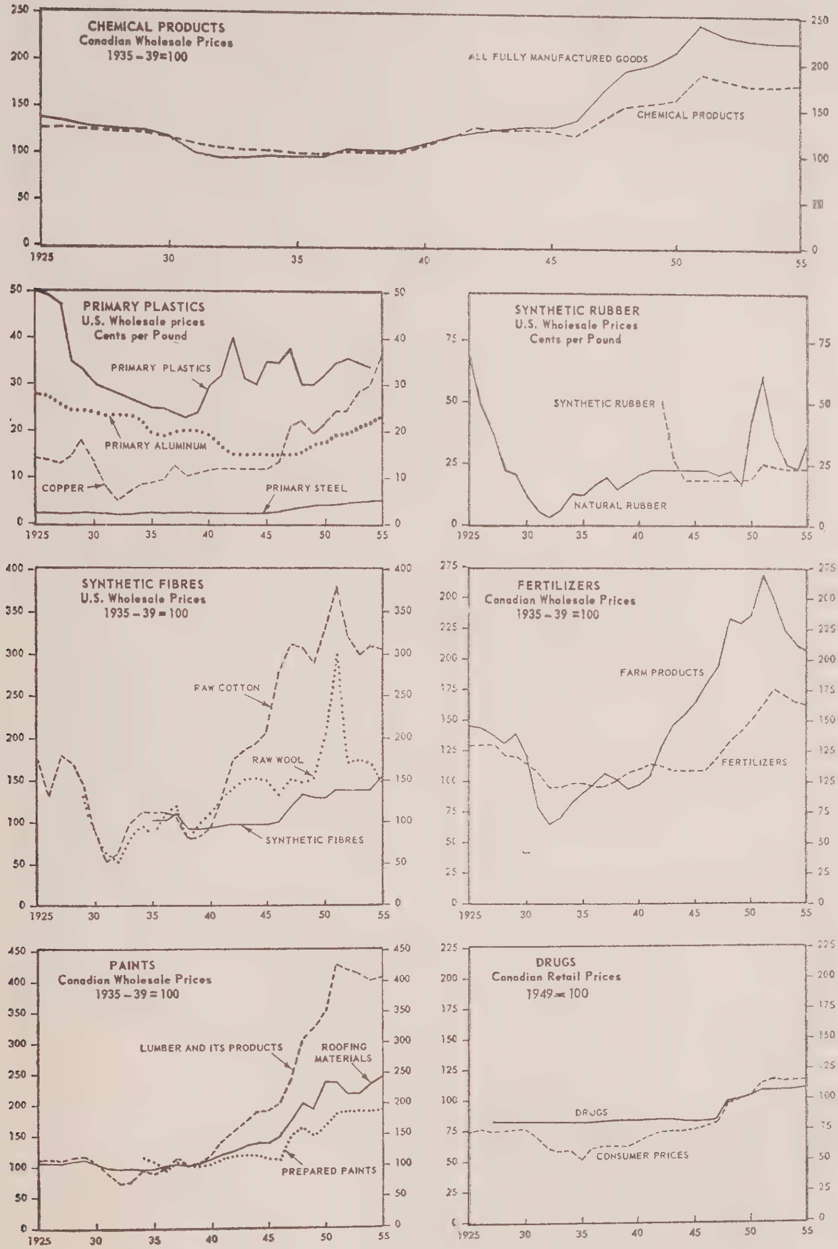
This petrochemical expansion, in which petroleum products are competing with other basic raw materials in the manufacture of heavy organic compounds, and in which the oil companies are vying with the other wholly chemical concerns, has been an outstanding feature of the war and postwar years.

More suitable raw materials, greater volume of production and more efficient processing, have resulted in a decline in the price of chemicals, not merely as compared with the prices of most other goods, but frequently in dollar terms as well. Indeed few other industries can boast of having held the line against inflation or of having helped to reduce the cost of living in comparable fashion. (See chart entitled Relative Price Movements for Chemicals and Other Products, 1925-55.)

Within the last decade or so many products have been developed which are now an accepted part of everyday living: synthetic fibres, plastics, synthetic rubber, detergents, DDT, penicillin, streptomycin and other chematherapeutic agents. The modern community can no longer do without them, partly because of their novel properties, and partly because alternatives from natural sources are no longer available in sufficient quantities to meet the world's needs.

Not only is the chemical industry becoming an integral part of the modern industrial community but it is gaining in flexibility. The materials from which it can choose are increasing in number and variety. The fact that many of its products are becoming more highly manufactured is also adding to the number of locations in which it can produce economically. Meanwhile, the demands which it serves are no longer confined to a few heavy industries. Employing research as a tool and technology as one of its major resources, it is striking out more and more on its own—particularly in new and rapidly expanding economies like Canada.

RELATIVE PRICE MOVEMENTS FOR CHEMICAL AND OTHER PRODUCTS
1925 – 1955



3

BACKGROUND OF THE CANADIAN CHEMICAL INDUSTRY

In the field of chemistry, Canadian scientists and engineers have been responsible for numerous firsts. Calcium carbide, the material from which acetylene is made, was first manufactured in quantity here. Canadians developed electrolytic processes for the manufacture of chemicals from salt which are still widely used today. North America's first acteylene-based acetone and acetic anhydride plants were also built in this country. The contact process for the recovery of sulphuric acid from smelter gases was also a major Canadian contribution. One could go on enumerating the new processes and modifications to existing techniques which Canadians have had to make in order to take advantage of local conditions, or to overcome the obstacles which they have sometimes entailed. Yet to labour this aspect of the Canadian chemical industry's development would be misleading. Most of the scientific information which it employs still comes through its connections with parent and affiliated firms in the United States and the United Kingdom.

The chemical industry, we find, is not new to Canada. Indeed, the burning and leaching of wood to make potash was one of the principal industries of the country a century ago. Produced by the early settlers as they cleared their land, it became the country's second most important export industry around the middle of the 19th century. It has been estimated that, at one time, as much as $1 million worth of this hardwood product was shipped overseas each year, largely to the United Kingdom, for the making of soap, glass and gunpowder.

This activity reached its peak around 1870, but it was doomed to lose out in the end. Not only was the clearing of agricultural land bound to diminish, but the discovery of extensive natural potash deposits around Stassfurt in Germany sounded its death knell. The result was that, by World War I, the asheries were virtually extinct, proving difficult to revive even as a stopgap measure when the German blockade was at its height.

For many years, factory production was confined to the manufacture of what are commonly termed inorganic chemicals. They were made from native resources such as mineral pyrites, limestone and salt, and demand for them arose out of the railway construction programme and developments

in the mining industry. Sulphuric acid, for instance, was first made in Southern Ontario in 1867, in conjunction with the local refining of oil. Then too, because the old-fashioned black powder could not shatter the hard rocks of the Precambrian Shield and the Western Cordillera, nitroglycerine had to be supplied in great quantities to take its place. This need for dynamite for tunnelling and other purposes resulted in the erection of several explosives plants, and the recovery of small quantities of by-product fertilizer, even prior to 1890.

In this period also the destructive distillation of wood, aimed at the recovery of methyl or "wood" alcohol and acetic acid, hit its peak. However, developments in the field of acetylene and pressure synthesis chemistry gradually put an end to this line of activity.

It was in the 1890's that electric power began to be used to effect chemical change. Canada, with its abundance of water power, was destined to play an important role in this field, and to make the industry more distinctly North American in character. Even before the turn of the century, phosphate chemicals and phosphorus for matches were being made at Buckingham, Quebec. This was closely followed by the setting up of a calcium carbide industry. Plants making this product and some of its derivatives were built around 1903 near Niagara and at Shawinigan Falls, to meet the rising demands for acetylene, first for lighting and later for welding purposes.

In 1908, cheap and adequate power also attracted to Niagara Falls what has since become the world's largest calcium cyanamide industry, and resulted in the establishment at Windsor, Ontario, of a plant to make caustic soda and liquid chlorine in 1911—several years before the same process was adopted in Great Britain, formerly the home of the alkali industry. Besides fertilizers, calcium cyanamide has since become the basis of cyanide compounds which play an important role in the recovery of precious metals from their ores. Cyanides, for example, were used at the Cobalt silver camp and are used today in many Canadian and foreign gold and silver mines. Canadian caustic was used in the manufacture of soap, and much of the chlorine from the alkali industry was used as a bleaching agent in the first pulp and paper mills. Export markets, too, were important, being in most cases, necessary in order to ensure efficient production in Canada.

Up until 1914, Canadian chemical concerns were almost entirely dependent on other heavy industries for their markets. However, during World War I they began to strike out on their own. The sixfold increase in volume of production achieved during the ensuing four years was due partly to the manufacture, for the first time in this country, of synthetic organic chemicals. Starting with calcium carbide, entirely new processes were employed for the manufacture of acetone and acetic anhydride. These new plants helped to overcome the serious bottlenecks which the Allies were encountering in obtaining a protective coating for airplane wing fabrics, and in procuring solvents for the manufacture of the propellant, cordite. Canada was therefore

playing a unique role in helping to overcome Germany's early supremacy in the realm of applied chemistry.

These were not the only new products whose manufacture was initiated in Canada as a result of World War I. A few of the more elementary drugs such as "aspirin" came into production when foreign supplies were cut off. The world's largest silicon carbide abrasives plant was built in Shawinigan Falls, and ferro alloys were produced at Welland, Ontario, to meet wartime requirements. Magnesite and brucite deposits in the Ottawa Valley were adapted to the manufacture of furnace refractories and new methods were worked out for using spruce pulp as a basis for viscose rayon manufacture. These and other related developments were destined to become a permanent part of Canada's future chemical industry.

In the interwar period, the driving force behind expansion came from two quite different directions. One arose out of increasing demands for process chemicals from other industries. The other was reflected in the growing tendency among chemical firms to make such consumer goods as soaps, pharmaceuticals and packaging materials, which could be sold direct at the retail level.

In the 1920's, for instance, rising chemical production was associated with demands emanating from the motor vehicle, oil refining, telephone, electrical apparatus and the pulp and paper industries. New factories for making accelerators and other rubber chemicals, fast-drying enamels, "Bakelite" type plastics and chlorine for bleaching, owed their origin to the expanding requirements of these other major industries. In the 1930's, on the other hand, the trend toward manufacture of consumer products by the chemical industry itself was more pronounced.

Not only was the ouput of synthetic textiles on the increase, but factories were also erected for the production of such things as "Cellophane", insulin, hormones, the sulpha drugs, paints and varnishes, and chlorinated organic compounds for non-flammable dry cleaning and metal cleaning. Despite the fact that foreign-owned concerns were in the majority, research along these lines was not entirely neglected by Canadian firms. Indeed, Canada's reputation was established in vitamin standardization; and the development of the vinyl resins, important ingredients of many of today's plastic film and coated fabric articles, began at Shawinigan Falls.

It was the interwar period also which saw the successful conversion of corrosive smelter fumes into fertilizers and other materials, a development which has had a beneficial effect not only on agriculture but also on mining and on the nation's export trade. Indeed, the successful recovery of sulphuric acid from smelter gases is claimed by some to have been one of the most outstanding contributions of the industry. For many years it had been necessary for Canada to rely almost entirely on the importation of elemental sulphur from Texas, the sulphur-bearing ores which this country possesses in

abundance being virtually ignored. In the search for cheaper raw materials, the industry turned to the corrosive gases which were already belching from the stacks of Canada's two largest base metal smelters.

In 1925, sulphuric acid was first made from the nickel smelter fumes at Coniston, Ontario, using a process which was later transferred to Copper Cliff in 1930. About the same time the problem of disposing of sulphurous gases from the lead-zinc smelter operations at Trail arose. This was successfully overcome in 1930 by converting these gases to sulphuric acid as an intermediate step in the large-scale production of ammonium sulphate and ammonium phosphate fertilizers. These developments, together with increased production of cyanamide chemicals at Niagara Falls and the erection of the first synthetic ammonia units at Trail and Windsor, did much to raise Canada into the front rank among the world's principal producers of nitrogenous fertilizers.

As the 1930's wore on, several other noteworthy projects got under way. Coal tar acids, as raw materials for the manufacture of paints and pharmaceuticals, were made for the first time, as was hydrogen peroxide for the bleaching of textiles. The production of acetylene derivatives was expanded both in volume and in variety, and the refining of radium-bearing ores by chemical means got under way at Port Hope, Ontario. These developments, some of which were encouraged by the protection afforded by Canadian tariffs, helped to offset cartel and other discriminatory regulations, which, as they were applied by the older producing countries, served to limit for a time Canada's export prospects.

As a result of the integration and strengthening of the chemical industry in Canada prior to World War II, it was possible, following the outbreak of hostilities in 1939, to embark almost immediately upon a great expansion of the chemical industry. Plants for the manufacture of heavy chemicals and explosives were rushed to completion, some 32 being built at a cost of more than $100 million in a period of just over three years. As a result, capital investment in the industry increased by approximately one-third, much of it in fields having lasting importance. This was particularly true in the case of nitrogenous fertilizers; together with existing synthetic nitrogen facilities, the new plants brought Canada's total nitrogen capacity in 1941 up to that of the annual prewar output of the United States. Due to the fact that the expected destruction of chemical plants in the United Kingdom did not occur, most of the new ammonium nitrate capacity soon became surplus to munitions requirements in Canada as early as 1943, and was converted to fertilizers to meet urgent Allied requirements.

Synthetic rubber, nylon yarn, by-product alcohol from sulphite pulp liquor, phthalic anhydride, aniline and new explosives were produced for the first time. Among the Canadian technical achievements in the war period may be cited the discovery of new and improved methods for making the explosives RDX and TNT, sodium azide and "Carbamite", and the adapta-

tion of wood cellulose as a raw material for the production of propellants in lieu of cotton linters. The Allies' only plant for the production of picrite, used in flashless cordite, was erected at Niagara Falls.

Since 1945 some of the explosives manufacturing capacity has been maintained in stand-by condition. It has, at the same time, been possible to use many of the wartime chemical plants to serve other industrial purposes. For instance, most of the new sulphuric acid capacity now serves Canadian rayon and fertilizer producers; the ammonia plants are being used to make fertilizers; the intermediate product for nitroguanidine (picrite) is a raw material for making plastics, while phthalic anhydride is used for making synthetic resins and plasticizers.

It had been expected by many that the end of hostilities would see a marked curtailment in activity in the chemical industry, but this did not come to pass. Indeed, the late 1940's were marked by a steady increase in civilian and export demands. Fertilizer production continued its upward trend as very large export demands were added to the continuing growth in domestic sales. The Canadian synthetic rubber, primary plastics and carbide-chemical industries also found foreign outlets for much of their surplus production. With the outbreak of war in Korea, and the subsequent increase in general business and defence activity, the chemical industry began adding substantially to the capacity with which it emerged from World War II. At this time a world shortage of sulphur caused new plants to be brought into production to recover sulphur values from natural gas, smelter fumes and sulphide ores. There was also a rapid expansion in the use of oil refinery by-products and natural gas constituents as sources of primary organic chemicals.

The postwar expansion has witnessed the beginning of production in Canada by a number of major United States firms which had previously supplied this country from factories elsewhere. Canadian metals and pulp producers, whose activities did not originally include chemicals, have in recent years branched out into the chemical industry proper or other phases of it, and several oil companies are producing petrochemicals either by themselves or jointly with others. This trend reflects two facts: that as chemical technology is more widely used in industry, the extraction and refining of material resources calls for quantities of basic chemicals which justify the manufacture of captive requirements, and that by-product utilization through chemical processing is frequently profitable or may be desirable for reasons of pollution control.

As the basic chemical industry moves nearer to the consumer with plastics, synthetic fibres, films, protective coatings, etc., and the manufacturers of end-products themselves integrate back to supply their own chemical needs, there is a marked breaking down of the former distinction between the chemical industry and others, and the latter is becoming increasingly difficult to define in any but rather arbitrary terms for statistical purposes.

4

THE CANADIAN CHEMICAL INDUSTRY TODAY

Introduction

The area of the economy dependent upon applied chemistry is widening. Today, one out of every three of the nation's manufacturing establishments employ chemical processes and make products which are essentially chemical in nature. Examples of such industries are the producers of metals, wood pulp, petroleum products, explosives, fertilizers, soap, paint, plastics, synthetic rubber, synthetic fibres, cement and glass.

However, this field is too broad for concise definition. Of the above-mentioned chemical process industries, a number are grouped together in a single Dominion Bureau of Statistics (D.B.S.) classification, Chemicals and Allied Products. This more limited group is considered to constitute the chemical industry for most purposes of this report. It includes manufacturers of both basic and synthetic industrial chemicals, as well as plants producing a variety of consumer products.

In order to emphasize its more basic function in the Canadian economy, the industrial chemical group has been separated in the report from the consumer product industries, which find their place in this classification only for reasons of statistical convenience.

The chemical and allied products industry is now producing goods valued at well over \$1 billion annually. In real terms, its value of production has increased over five times what it was in the late 1920's. The following table gives some indication of the growth in markets, and the changing pattern of supply over the past 35 years.

Through this period production has tended to increase in a series of steps. It rose steadily throughout the 1920's, and from 1935 up until the end of World War II. The recession of the early 1930's was shortlived, witnessing a drop in output from the 1929 level of less than one-third. Again, right after the end of World War II, production fell off somewhat, but rose again until in 1951 it passed the wartime peak of 1943. Since then the average annual increase in production has been in the order of \$70 million.

Canadian Chemical Production and Trade
(1920-55)

Value in $ Millions

Year	1920	1925	1930	1935	1940	1945	1950	1951	1952	1953	1954	1955
Canadian production	129	110	133	127	223	540	719	866	887	981	1021	1150[a]
Imports	58	39	53	44	69	109	212	259	232	272	256	314
Exports	23	18	17	17	32	125	109	139	132	148	176	220
Domestic supply	164	131	169	154	260	524	822	986	987	1105	1101	1244
Imports as % of dom. supply	35.4	29.8	31.4	28.6	26.5	20.8	25.8	26.3	23.5	24.6	23.3	25.2
Exports as % of production	17.8	16.4	12.8	13.4	14.3	23.1	15.2	16.1	14.9	15.1	17.2	19.1

[a]Preliminary figures.

Over the past five years some 15% to 20% of total Canadian production has been exported. This is lower than the achievements of the wartime period when explosives made up a sizable proportion of chemical exports, yet appreciably higher than the 1930's when as little as 10% of output was exported.

The export market has changed considerably over the years, in terms of both destination and type of product. In the late 1920's over half of total chemical exports were destined for the United States. This ratio fell all through the 1930's and up to the early war years. In 1941, barely one quarter of Canadian export trade in chemicals was with the United States. Since that period, however, that market has continued to receive about 50% of the chemical products shipped outside this country. The United Kingdom on the other hand was a very small purchaser until the war years when the flow of explosive materials increased their share of trade to about 25% of total Canadian exports. More recently an average of 10% to 15% has applied. Other countries, as a group, have continued to purchase from a quarter to a third of our total exports. The share of our export market for 1955 was in the order of: United States, 50%; United Kingdom, 10%; other countries, 40%.

Fertilizers have continued to be the largest single export category, although Canada's sales abroad of primary plastics over recent years have been substantial. Synthetic rubber, vegetable oils, acids and salts as well as sizable shipments of pharmaceuticals have helped to swell the total.

Imports have always supplemented Canadian production in supplying the home market. Over $300 million worth were imported in 1955, equal to one-quarter of total Canadian consumption. However, Canada is less dependent upon imports today than in the 1920's or 1930's. In those earlier periods 30% to 35% of our total requirements were met by foreign producers.

Although such exported products as primary plastics and synthetic rubbers have helped to broaden the export base, Canada's source of imports is much more concentrated. Producers in the United States have gradually increased their share of the Canadian market and today supply fully 85% of total Canadian imports. Germany is no longer one of this country's major suppliers. The United Kingdom, which consistently supplied from 10% to 15% of Canadian imports up until the mid-war years, now supplies only 7% to 10%.

Prior to the advent of plastics in large volume, imports of acids and salts were the largest import item. Today, however, imports of plastics and plastic products account for a fifth of total Canadian chemical imports. These are followed in order of importance, by pharmaceuticals, pigments and vegetable oils.

Balancing production, exports and imports, we arrive at the apparent domestic consumption of chemicals. In 1955 Canada consumed $1.25 billion worth of these products, or five times the value of the prewar years. In real terms, after excluding price movements, the market has expanded nearly four times from that of the period 1926 to 1930.

In relation to the rest of the economy, we find that Canadian chemical consumption is to-day equal to about 5% of the GNP whereas in 1929 it was of the order of 2.3%. However on the employment side, the industry does not make nearly as impressive a showing. The 51,000 workers in this industry represent less than 1% of total employment in the nation. This bears out the many references to the capital intensity of the industry.

Employment has increased only threefold since 1929, whereas the industry's physical capacity (as expressed in terms of value of production in constant dollars) has risen around fivefold. Labour productivity is obviously gaining, and gaining rapidly, as plant sizes increase and greater resort is had to automation. These continuing additions to capacity, together with the demands of obsolescence created by technological progress, have raised the industry's annual investment in new plant and equipment in Canada to well over the $100 million a year level.

Despite these large outlays on plant and equipment, the location of the industry has changed but little. New chemical centres such as Sarnia, Arvida and now Edmonton have been added to the older locations at Toronto, Windsor, Montreal, Hamilton, Trail and Niagara Falls. But the chemical industry is still concentrated in the central provinces. Fully 90% of those finding jobs with this industry are employed in Ontario and Quebec.

Industrial Chemicals

General

For the purpose of this study, Canada's chemical industry can be broken down into two groups: producers of basic chemicals (used primarily by the

chemical industry itself and by other industries), and producers of allied chemical products whose output is sold through wholesale and retail outlets directly to the ultimate consumer.

The first of these broad categories, the producers of industrial or basic chemicals, is taken to include those making heavy chemicals known by their chemical names, such as acids, alkalies, and salts, as well as the wholly chemical but less clearly defined groups such as primary plastics, synthetic rubber, coal tar products, compressed gases, and fertilizers in bulk.

The following table gives some indication of the size and relative importance of the component industries classified in the industrial chemicals group.

Composition of the Industrial Chemicals Group

1955

Sub-groups	Number of plants	Number of employees	Selling value of products $ millions	%
Acids, alkalies & salts	46	8,642	175.3	25.5
Fertilizers	39	2,947	93.0	13.5
Primary plastics	23	2,920	75.5	11.0
Coal tar distillation products	11	532	12.8	1.9
Compressed gases	47	1,390	17.8	2.6
All other[a]	266	14,171	313.2	45.5
Total	432	30,602	687.6	100.0

[a]The list of "all other" categories includes:
(i) establishments producing such chemical products as synthetic fibres (though their production is often included with that of the textile industry), and
(ii) the production of chemical products by other firms whose principal activity is other than the production of chemicals, *i.e.* the production of steel or the smelting and refining of non-ferrous metals.

Plants classified as belonging to the industrial chemical group in 1955 accounted for some 60% of the nation's total output of chemicals and allied products, compared with 42% 20 years ago. Much of the gain since the end of World War II has been due to the construction of large plants producing such materials as synthetic fibres and primary plastics.

The relationship of industrial chemical production to consumption over the past quarter century is computed by the following statistics.

Production and Consumption of Industrial Chemicals — Canada

(thousands of dollars)

	1929	1935	1940	1945	1950	1953
Production from chemicals & allied products industry	60,696	48,448	94,511	295,089	310,198	462,032
Production outside the industry[a]	5,952	4,931	23,338	40,912	71,701	95,853
Total production	66,648	53,379	117,849	336,001	381,899	557,885
Imports (*Trade of Canada*, chemicals & allied prod. series)	29,232	24,057	43,931	63,811	131,322	188,527
Other imports	5,827	3,202	7,145	17,819	19,103	23,672
Total imports	35,059	27,259	51,076	81,630	150,425	212,199
Supply	101,707	80,638	168,925	417,631	532,324	770,084
Exports (*Trade of Canada*, chemicals & allied prod. series)	19,839	13,661	28,308	99,084	95,684	131,500
Other exports	—	—	—	8,755	2,879	3,490
Re-exports	n.a.	n.a.	404	746	1,416	1,727
Total exports	19,839	13,661	28,712	108,585	99,979	136,717
Apparent consumption	81,868	66,777	140,213	309,046	432,345	633,367
Total production as a percentage of apparent consumption	81.41	80.00	84.05	108.72	88.33	88.08
Total imports as a percentage of apparent consumption	42.82	40.82	36.43	26.41	34.79	33.50

[a]See footnote to preceding table.

The above data are conclusive in several respects. They show quite clearly that:

(a) World War II greatly stimulated production.

(b) Over the period, Canada's self-sufficiency has increased from 81% to 88% of apparent consumption.

(c) Exports as a percentage of total Canadian industrial chemicals production have declined from 30% in 1929 to around 25% at the present time.

The following table showing consumption by principal industrial users illustrates the range of consuming industries served by industrial chemicals.

(See also charts illustrating Principal Canadian Chemical Using Industries —Long Term Production, Trends and Consumption, 1953.)

Consumption of Industrial Chemicals in Canada, 1953

Consumption categories:	Thousands of $	% of Total
Industrial chemicals	95,069[a]	15.1
Consumer and allied products	54,930[a]	8.7
Direct consumer use	27,486[a]	4.4
Industrial uses		
Agriculture	75,320	12.0
Plastics fabrication	20,386	3.3
Mining, smelting & refining	32,608	5.2
Construction & maintenance	5,300	0.8
Foods, packaging	46,563	7.4
Pulp & paper	47,215	7.5
Rubber & leather products	59,698	9.5
Steel products	11,065	1.8
Petroleum products	13,924	2.2
Electrical products	3,971	0.6
Textile products	92,639	14.8
Wood products	3,342	0.5
Miscellaneous	38,791	6.2
Total apparent consumption	628,307[a]	100.0

[a]This total differs from that reported in the previous table by $5,060,000 which is the amount of Allied Products made in the Industrial Chemical Group.

This table clearly illustrates that the firms classified in the industrial chemicals group sell most of their production to other domestic industries; less than 5% goes directly to consumer uses. Of the 95% going to primary and secondary industry, nearly one-quarter (23.8%) is absorbed by the chemical industry itself; moreover, some 15% is sold by one producer of industrial chemicals to another. In other words, 15% of these sales would not be recorded if this group of industries were completely integrated and its output reported exclusive of internal transfers.

Next to the industrial chemicals group itself, the nation's textile mills appear to be the largest single customer, their purchases consisting largely of fibres, chemicals and bleach. Agriculture, buying fertilizers and insecticides, is the second largest market while rubber and leather products come third.

It is also possible to break this group down into component or sub-industry categories, each of which differs as to markets and relative rates of growth. The accompanying chart, entitled Production of Industrial Chemi-

cals—Canada, Value of Production 1955 and Physical Rates of Growth, shows that, with the exception of primary plastics, the average yearly increase in sales over the past two decades has been between 6% and 11%.

Acids, Alkalies and Salts (Basic Chemicals)

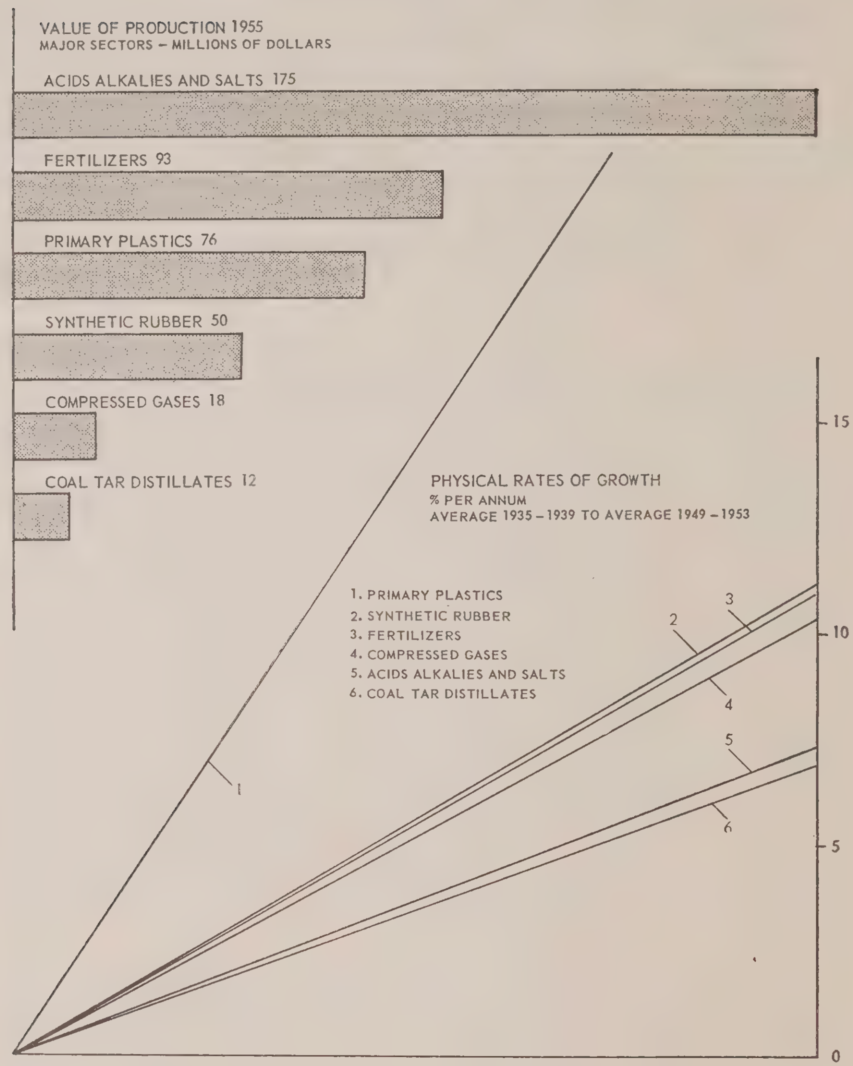
The acids, alkalies and salts industry is at once the largest, the most basic and the most complex of all the sub-groups within the chemical industry. Its plants account for over 25% by value of the nation's total output of industrial chemicals; in excess of 15% of all Canadian chemical production.[1] It includes many of the largest, best integrated and most expensively equipped establishments. Starting, in the main, from raw materials, it produces a wide and ever-growing range of chemical substances, the great majority of which are sold to other primary and secondary manufacturing concerns for further treatment or further incorporation in their final products.

The importance of the acids, alkalies and salts sub-group cannot, however, be delineated by statistics. Its contribution has its qualitative aspects as well. Through the distinct nature of its output and the highly specialized know-how which it is continually bringing to bear upon many of the nation's industrial problems, it has added considerably to Canada's economic status. Without chlorine, much of the nation's output of wood pulp could not be bleached economically. Without a ready supply of mineral acids (sulphuric, hydrochloric, nitric, etc.) most of the metal and energy producing industries would be seriously handicapped. This applies with particular force to petroleum refining, the manufacture of fertilizers, food processing, the separation of metals from their ores and the manufacture of primary iron and steel. Various large-volume organics have also become important building blocks for modern industry. The manufacture of synthetic textiles, articles made from plastics, and even structural materials such as adhesives for the production of plywood, must be produced locally if costs are to be kept at a reasonable level. The basic chemicals, in other words, are vital materials, whose supply helps to determine the competitive nature of many of Canada's other primary and exporting industries, as well as those secondary industries which serve the domestic market.

This central group performs another function. Research and development conscious as it is, it serves as a training ground for many of the chemists and the chemical engineers who subsequently find employment in the other chemical process industries. The results of its efforts in the fields of both fundamental and applied research are continually appearing and reappearing in the process, techniques and operations of other industries which, in one way or another, also employ the science of chemistry and chemical methods. Despite the pioneering work done by certain firms and the gestures made in this direction by others, however, it would be

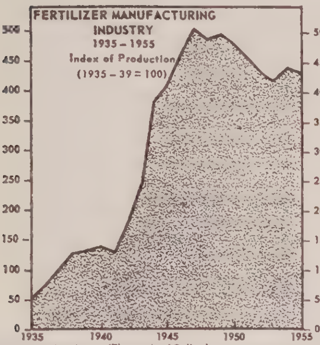
[1]Acid, alkalies and salts production in 1955 amounted to $175 million.

PRODUCTION OF INDUSTRIAL CHEMICALS – CANADA



Principal Canadian Chemical Using Industries
Long-Term Production Trends and Consumption 1953

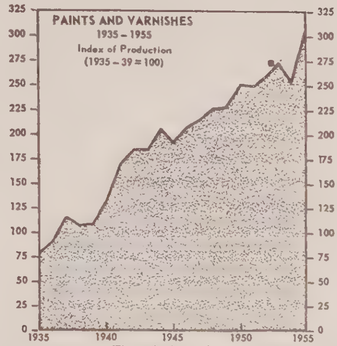
CHART 1



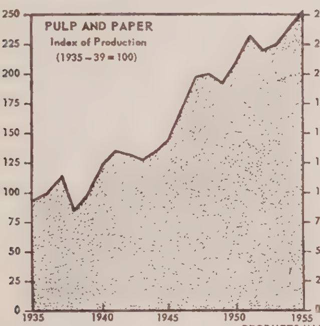
CHEMICALS USED (Thousands of Dollars)		PRODUCTS MADE	
SUPERPHOSPHATE	9,072	MIXED FERTILIZERS	32,751
POTASSIUM CHLORIDE	3,900	FERTILIZER CHEMICALS	48,866
SULPHURIC ACID	2,914	SUPERPHOSPHATE*	520
ANHYDROUS AMMONIA	3,042	AMMONIUM SULPHATE*	38
AMMONIUM SULPHATE	2,056	MURIATE OF POTASH	85
ALL OTHERS*	5,756	ALL OTHERS	9,382
TOTAL	26,740	TOTAL	91,642

*EXCLUDING PHOSPHATE ROCK

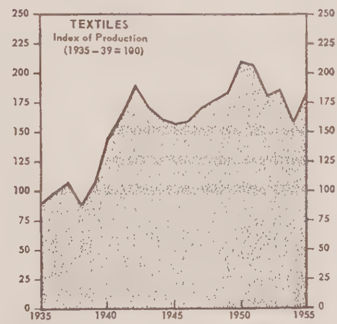
*MILLED AND SCREENED ONLY



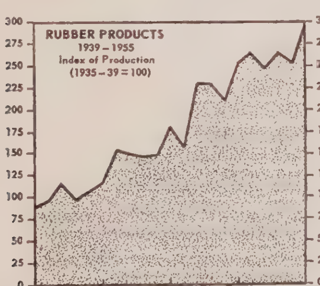
CHEMICALS USED (Thousands of Dollar)		PRODUCTS MADE	
VEGETABLE OILS	9,224	READY MIXED PAINTS AND ENAMELS	72,825
TITANIUM DIOXIDE PIGMENTS	7,186	VARNISHES	8,951
OTHER PIGMENTS	8,286	LACQUERS	7,536
SYNTHETIC RESINS	6,586	WATER-THINNED PAINTS	10,202
SOLVENTS	7,414	THINNERS	3,471
ALL OTHERS	6,191	PASTE PAINTS	1,002
		ALL OTHERS	9,261
TOTAL	44,887	TOTAL	113,248



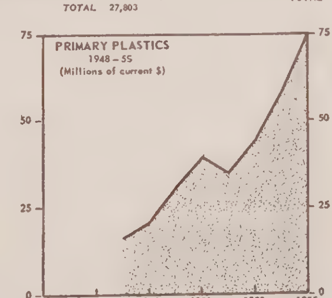
CHEMICALS USED (Thousands of Dollars)		PRODUCTS MADE	
SULPHUR	8,293	PULP – MECHANICAL	209,899
LIQUID CHLORINE	6,051	CHEMICAL	406,114
SALT CAKES	3,827	OTHER	8,852
CAUSTIC SODA	5,719	PAPER – NEWSPRINT	633,408
LIME	3,209	BOOK & WRITING	61,451
ALUM	2,322	WRAPPING	49,028
ALL OTHERS	17,794	PAPER BOARDS	114,978
		OTHER	28,993
TOTAL	47,215		



CHEMICALS USED (Thousands of Dollars)		PRODUCTS MADE	
DYE STUFFS & BLEACHES	6,101	COTTON YARN & CLOTH	220,451
PROCESSING OILS	3,105	OTHER COTTON GOODS	10,738
STARCHES	1,424	WOOLLEN CLOTH	61,441
ACETIC ANHYDRIDE	1,100	WOOLLEN YARN	36,031
CAUSTIC SODA	1,185	OTHER WOOLLEN GOODS	45,397
CARBON BISULPHIDE	810	SYNTHETIC & SILK	146,418
SULPHURIC ACID	904	ALL OTHERS	180,215
ALL OTHERS	13,174	TOTAL	700,691
TOTAL	27,803		



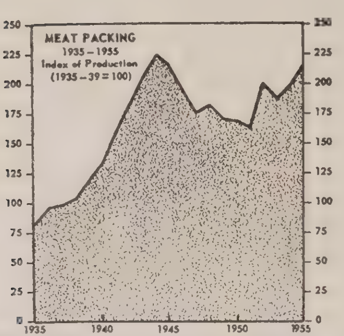
CHEMICALS USED (Thousands of Dollars)		PRODUCTS MADE	
SYNTHETIC RUBBER	18,749	TIRES & TUBES	156,546
CARBON BLACK	4,409	FOOTWEAR	35,916
SYNTHETIC RESINS & PLASTICS	2,515	HOSE	9,361
ZINC OXIDE	1,102	BELTING	9,442
PLASTICIZERS	1,306	RUBBERIZED CLOTHING	1,858
ACCELERATORS	1,170	RUBBER SOLING & SLAB FOR HEELS	3,540
ALL OTHERS	8,190	ALL OTHERS	74,072
TOTAL	37,441	TOTAL	290,735



CHEMICALS USED (Thousands of Dollars)		PRODUCTS MADE	
PHTHALIC ANHYDRIDE	729	SYNTHETIC RESINS – POLYSTYRENE – VINYL CHLORIDE – PHENOL-FORMALDEHYDE	19,006
PLASTICIZERS	967	FILM, SHEETING & GRANULATED	15,710
PHENOL	1,434	ALL OTHERS	9,826
FORMALDEHYDE	623		
GLYCERINE	940		
ALL OTHERS	17,466		
TOTAL	22,159	TOTAL	44,542

Principal Canadian Chemical Using Industries
Long-Term Production Trends and Consumption 1953

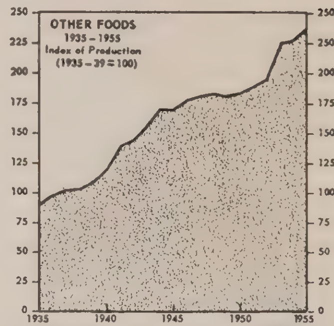
CHART 2



CHEMICALS USED (Thousands of Dollars) PRODUCTS MADE

Chemicals used	
COTTON SEED OIL	7,526
SOY BEAN OIL	13,196
COCOANUT OIL	5,533
PEANUT OIL	122
SUN FLOWER OIL	413
MARINE OIL	1,802
ALL OTHERS	12,068
TOTAL	40,660

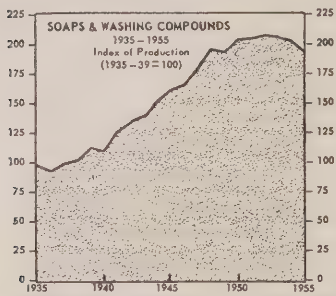
Products made	
FRESH & FROZEN MEAT – BEEF	249,514
– PORK	158,705
– OTHER	74,364
CURED MEATS	236,477
LARD & SHORTENING	63,104
HIDES & SKIN	14,840
ALL OTHERS	32,464
TOTAL	829,468



CHEMICALS USED (Thousands of Dollars) PRODUCTS MADE

Chemicals used	
VEGETABLE & OTHER OILS	27,352
GELATINE	1,570
CARBON DIOXIDE	1,098
ALCOHOL	1,832
MONO-SODIUM GLUTAMATE	825
STARCH	1,402
ALL OTHERS	15,814
TOTAL	49,893

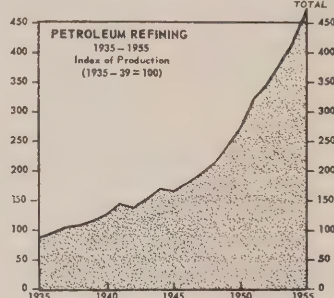
Products made	
SUGAR	117,952
CARBONATED BEVERAGES	95,228
COFFEE	72,113
TEA	41,068
VEGETABLES, CANNED	50,467
SYRUPS, CONCENTRATES & EXTRACTS	15,846
FRUITS, CANNED	19,015
ALL OTHERS	1,274,393
TOTAL	1,686,082



CHEMICALS USED (Thousands of Dollars) PRODUCTS MADE

Chemicals used	
COCOANUT OIL	2,489
OTHER VEGETABLE OILS	1,398
SODIUM HYDROXIDE	1,419
SODIUM TRIPOLYPHOSPHATE	3,385
TETRA SODIUM PYROPHOSPHATE	1,645
GLYCERINE	1,123
ALL OTHERS	3,058
TOTAL	14,517

Products made	
SOAP – HARD	34,560
– LIQUID OR SOFT	1,877
SYNTHETIC DETERGENTS	28,704
TOILET PREPARATIONS	8,382
GLYCERINE	4,201
SCOURING POWDERS PASTES AND CAKES	4,425
ALL OTHERS	15,175
TOTAL	97,324

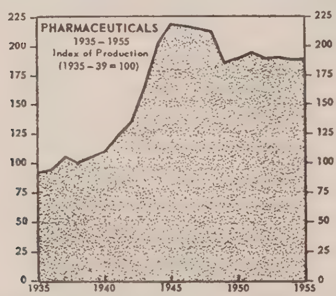


CHEMICALS USED (Thousands of Dollars) PRODUCTS MADE

Chemicals used	
SULPHURIC ACID	267
CAUSTIC SODA	487
PHENOL	192
DYES	126
TETRAETHYL FLUID	10,765
INHIBITORS	336
ALL OTHERS	122
TOTAL	12,295

Products made	
MOTOR GASOLINE	348,325
HEAVY FUEL OIL	76,733
LIGHT FUEL OIL	79,770
DIESEL FUEL	39,378
STOVE OILS	40,301
LUBRICATING OILS AND GREASES	25,216
ALL OTHERS	70,238
TOTAL	679,961*

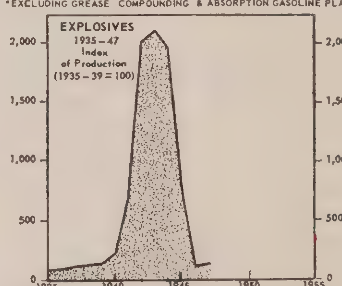
*EXCLUDING GREASE COMPOUNDING & ABSORPTION GASOLINE PLANTS.



CHEMICALS USED (Thousands of Dollars) PRODUCTS MADE

Chemicals used	
VEGETABLE DRUGS	387
ETHYL ALCOHOL	542
PENICILLIN	431
SULPHA DRUGS	471
GLYCERINE	571
ACETYLSALICYLIC ACID	421
ALL OTHERS	5,123
TOTAL	7,946

Products made	
PATENT MEDICINES	18,560
VITAMINS & HORMONES	20,583
ANTIBIOTICS	9,399
ETHICAL SPECIALTIES	28,841
HUMAN MEDICINES N.O.P.	8,302
ALL OTHERS	1,413
TOTAL	87,098



CHEMICALS USED (Thousands of Dollars) PRODUCTS MADE

Chemicals used	
ANHYDROUS AMMONIA	1,343
ETHYLENE GLYCOL	1,148
GLYCERINE	1,540
SODIUM NITRATE	977
SULPHURIC ACID	900
AMMONIUM NITRATE	287
ALL OTHERS	1,690
TOTAL	7,885

Products made	
AMMUNITION, DETONATORS, SHELLS, GUNPOWDER ETC.	77,150

wrong to imply that the majority of companies in this group has made as much of a contribution, where innovations are concerned, as their counterparts in the United States, the United Kingdom or Germany. Nevertheless, there appear to be numerous grounds for referring to the acids, alkalies and salts sub-group as the backbone of the chemical industry.

Present structure

As presently constituted, the acids, alkalies and salts industry includes some 40 plants, 25 of which are engaged in the production of large-volume chemicals for sale or resale to other industries. That it is dominated by a goodly number of large and internationally well-known firms is illustrated by the fact that a mere 16 companies produce over 80% of its value of output. Of these, a great majority have strong international ties. Ten are wholly or partly owned subsidiaries of United States corporations;[2] two are wholly or partly owned in the United Kingdom;[3] only four are divisions of major Canadian chemical concerns.[4] It is, perhaps, worth noting also that the latter are backed up, financially and through research, by corporate activities in other and related fields—especially in metals and in the production of power.

The locational characteristics of this important industrial sector are numerous. Certain plants, and these are among the largest, have been built to service the needs of other resource industries, particularly those producing metals or engaged in the recovery of their by-products. These are to be found in the outlying areas, either close to a large mining district or in the West close to the oil and gas fields. The remainder are concerned primarily with sales to secondary industry. This, no doubt, explains why about four-fifths of the industry's total capacity is concentrated in Ontario and Quebec. There are exceptions. In certain instances, a ready supply of cheap raw material or low cost energy—or both—has had something to do with the siting of these plants. Thus, the availability of natural gas in Alberta has had a tendency, in recent years, to attract new projects of this kind. Again, when the main purpose has been to serve the export trade, seaboard locations or points where materials, power and skilled labour could be readily assembled have been chosen with a view to minimizing transportation and other costs. Because of all this, the group as a whole appears to be largely market oriented. Its future growth will therefore tend to parallel that of industrial development generally.

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[2]Monsanto (Canada) Ltd., Dow Chemical of Canada, Ltd., Du Pont Co. of Canada Ltd., North American Cynamid Ltd., Aluminum Company of Canada Ltd., Brunner Mond Canada Ltd., Nichols Chemicals Co. Ltd., Union Carbide (Canada) Ltd., and Canadian Chemical Co. Ltd. are the largest.

[3]Electric Reduction Co. of Canada and Canadian Industries Limited.

[4]Shawinigan Chemicals Ltd., Consolidated Mining and Smelting Co. of Canada, Ltd., Dominion Tar and Chemical Co. Ltd., and St. Maurice Chemicals Ltd.

Products made

To some it is convenient to draw a distinction between the several categories of products made by the basic chemicals industry. The terms "primary" and "secondary" are sometimes employed. Still in use are the opposites—"heavy" and "fine". They are meant to distinguish between the bulkier low-cost items and the specialty products. Then there is the more precise terminology used by the chemists themselves, that of "organic" and "inorganic". Confusing, in that they distinguish in quite different ways between the multitudinous products of the basic chemical-producing plants, they are nevertheless, in their own way, descriptive of the great number and variety of products which these establishments turn out.

Primary chemicals, for example, may be thought of as those which are produced direct from raw materials, such as salt, gypsum, potash, natural gas, coke, limestone and the mineral sulphides. Secondary chemicals, on the other hand, are usually produced with the aid of chemical intermediates —that is, from other basic chemicals—thus typifying a more advanced stage of manufacture.

Heavy chemicals, meanwhile, are of the basic industrial variety. Obviously they include commodities like sulphuric acid, calcium carbide, ammonia, caustic soda and chlorine, all of which are produced in considerable volume and sold at comparatively low unit prices to other industrial users, the majority of which are themselves often engaged in primary processing. Fine chemicals, by comparison, are usually made in small batches to exacting standards and for a single or limited range of use. Though the distinction between "heavy" and "fine" chemicals was first applied to inorganics, it has more recently prevailed in the organic field as well. Ethylene glycol, for example, is a typical heavy organic. A product like monosodium glutamate, a flavour enhancing substance used in soups and other foods, is a fine organic chemical.

As the name acids, alkalies and salts implies, the principal products of these plants are inorganic in nature. However, organic chemicals produced by chemical synthesis, whether from coal, coke or natural gas, are also commonly included in this sub-grouping. Here we now find the complex nylon intermediate, hexamethylene diamine and the now popular resin constituent, pentaerythritol. The so-called petrochemicals, except those produced exclusively for the production of plastics, soap, paint, synthetic rubbers and the man-made fibres, are also included here. Thus, a category which was once heavily weighted with the major inorganics has become progressively more representative of their function; that of supplying the basic needs of other industries. Hence, the even briefer terminology used here, that of basic chemicals.

Statistically, it is difficult to describe this industry's structure with anything like the same degree of precision. Production data for a few major products can, of course, be abstracted from the total. Chlorine, caustic soda

and sulphuric acid alone account for some 20% of the total value of the output of this group. Between 40% and 45% of its total value of production are organics, the rest, of course, being inorganics by definition. A comparable analysis in any previous year would doubtless show the changing relationship between the two. In 1939 only about 20% of all the basic chemicals produced in this country were of the organic variety. Thus, between the late 1930's and the mid 1950's, their output has more than doubled in importance, while that of the inorganics has fallen from 80% to something less than 60% of total production.

A directory attempting to list all of the inorganic chemicals at present manufactured in this country would run into many dozens of pages. Suffice it to say that, besides those mentioned previously, others of major significance include aluminum sulphate, aluminum fluoride and aluminum chloride; hydrogen peroxide; phosphorus, phosphoric acid, sodium phosphates and other phosphorus compounds; sodium and potassium chlorates; calcium chloride and soda ash; carbon black; sodium sulphite and zinc chloride; liquid sulphur dioxide, carbon disulphide, and ammonia. This list encompasses the major heavy inorganics required by the pulp and paper industry, by secondary groups of the chemical industry, and by most other Canadian extractive and manufacturing industries. In these, Canada is to a marked degree self-sufficient, supplying a high percentage of her own needs with a relatively complete range of chemicals.

Heavy organic chemicals produced within the industry include first, the products of calcium carbide—acetic acid, and a whole range of its derivatives including acetic anhydride, vinyl acetate, acetaldehyde and monochloroacetic acid. Many of these chemicals have been produced at Shawinigan Falls since the 1914-18 war. More recent developments include the production at Sarnia of such organic solvents as trichlorethylene (a metal cleaner), perchlorethylene (a fabric cleaner), and carbon tetrachloride. In Maitland, a major plant makes the long-named chemicals that combine to form nylon; adipic acid and hexamethylene diamine. From the several petrochemical plants that have recently sprung up beside the great refineries come carbon black, acetone, phenol and isopropyl alcohol. Formaldehyde is made at three locations, ethylene glycol at two, and pentaerythritol at two. And this paragraph could be carried to considerably greater length by a mere enumeration of the other alcohols, glycols, ketones, aldehydes and so on made in the industry.

The fine chemicals, though less important in dollar volume, represent a very respectable range of products. They include first of all the specially purified inorganic chemicals supplied as laboratory reagents and phamaceutical raw materials. The organic chemicals fall into a number of general classes. There is a whole range of paint additives, drying oils to promote quick hardening of the paint film and antioxidants to prevent paint deterioration, among others. Rubber chemicals include the accelerators which hasten

rubber curing, and again a range of antioxidants. Some fine organics, such as citric acid and sodium benzoate, are made principally for use in foods and beverages. There are plasticizers, (chemicals added to plastic products in order to increase their usefulness), chemically-treated fatty acids and many others.

In total, however, the heavy and fine organic chemicals, taken together, form nothing like as complete a range as do the inorganics made in Canada. At present, they number only about 500. Such a count would appear to be impressive were it not for the fact that over 7,000 are now in production in the United States. Several thousand different organics are in production in the United Kingdom. In Western Europe, where the organic chemical industry had its early commercial beginnings, the number and variety produced are also considerable. Shortly they too will be in excess of 5,000 by actual count.

Markets served by the industry

The markets for heavy chemicals are, in the main, domestic markets. Being low in unit price and expensive to transport, plants for their production are usually located close to their point of ultimate consumption. Often these chemicals can be produced using techniques which are widely known; usually they can be made from raw materials which are either widely distributed or are themselves much more readily transportable. Proof of this fact lies in the extent to which the basic chemicals enter international trade. In 1955 only about 10% of the total output of Canada's acids, alkalies and salts industry was exported. A comparable figure for the United States was 7%. Imports into Canada, at one time appreciable, now account for only about 23% of domestic consumption. In the more highly industrialized countries, the proportion is much lower. Thus, in contrast to the movement between countries of coal, oil, non-ferrous metals and even chemical products like fertilizers, the tendency toward local self-sufficiency in this industry appears to be both considerable and economically well founded.

Domestic market considerations are therefore dominant. Being still the most important, both in value and volume terms, the heavy inorganics are dealt with first. They, it seems, are shipped in greatest quantity to producers of basic organic chemicals, as well as to other producers nominally falling within the definition of the chemical industry proper. They are irreplaceable as process chemicals in making plastics, fertilizers, soaps, pharmaceuticals, explosives, synthetic rubber and the man-made fibres. As previously mentioned, they are also required in the metals processing and forest products industries. They are needed in the manufacture of abrasives, the fabrication of machine and consumer durable components and they are sold in considerable volume to the building materials producers as well.

The association between natural resource utilization and the producers of basic chemicals is readily explained. Often the production of these chem-

ical products marks a further stage of integration within the parent industry, be it metal mining and processing, the manufacture of forest products or simply the processing of such food materials as the vegetable oils.

The pulp and paper industry, for example, is the largest consumer of sulphur compounds and of Canadian-produced chlorine and caustic soda; it also uses salt cake, ammonia, hydrogen peroxide, alum and a number of other chemicals, not a few of which are produced directly or as by-products from its own internal operations. The smelting of metal ores consumes great quantities of chemicals; xanthates for flotation, cyanides for gold recovery, caustic soda and soda ash for aluminum production. In recent years with the development of the so-called chemical leaching processes for refining, such chemicals as caustic soda, sulphuric acid and ammonia have become so important to producers of uranium and nickel that refiners have in several cases built captive plants to supply their own needs.

One of the most persuasive trends in mineral processing in recent years has been that associated with chemical leaching. Chemical treatment, frequently employing high temperatures or pressures, has successfully replaced older pyrometallurgical methods for the recovery of such metals as nickel, cobalt, copper and uranium. It offers considerable promise with respect to lead, zinc and titanium. In Edmonton, the Canadian-developed Forward process, employing an ammonia solution, is currently being used to dissolve metal values from the complex Lynn Lake ores. Uranium concentrates are commonly either treated with caustic soda, or leached by means of sulphuric acid. The sulphuric acid itself can come from other mining operations. Iron pyrites, so widespread in occurrence, is thus being put much more effectively to work. Hydrochloric acid, employed in a number of metallurgical processes, notably the recovery of tungsten, is also being made and used in western Canada for the acidizing of oil wells. The manufacture of many such commodities, it appears, is dependent upon the discovery of some unique and exportable resource.

While it is true that the great majority of heavy inorganic chemicals are put to work in this country and not themselves exported, their prospects are interwoven inextricably with that of the nation's export trade. It has recently been estimated that some 60% of all Canadian inorganic chemical production is being used in the manufacture of products which themselves are subsequently sold abroad. Less well known is the fact that, in selling to these extractive and related industries, Canada's producers of basic chemicals have had little tariff protection. Being exporters, the great majority of their customers are able to obtain a rebate to the extent of 99% of all the duties which they pay on materials brought in from outside the country. This applies, equally, to heavy chemicals. Thus, the Canadian industry—to the considerable extent that it is dependent upon the nation's export industries for sales—is without tariff protection. The fact that it has

grown at all speaks well of the efficiency of Canadian producers in this field. Their production, on the other hand, has remained small relative to that of the United States and certain other countries because of the ease of access which their parent organizations have had to the Canadian market for many of the heavy chemicals used in the newer methods of processing.

The market situation with regard to the heavy organic chemicals is somewhat different. Many of them, indeed the majority, are used at a relatively advanced stage of manufacture. Thus, ethylene glycol is merely mixed with certain additives, packaged and sold as anti-freeze; the same is true of a number of alcohols. Pentaerythritol is a raw material for the manufacture of certain alkyd resins, used for paints sold direct to the consumer. Heavy organics are typically solvents—used in many a secondary manufacturing establishment—or chemical intermediates, the raw materials for chemical synthesis which results in the production of dyes, food additives and drugs.

Markets for these organic chemicals depend upon three factors: the strength of the Canadian demand for consumer goods, the size and relative rate of growth of secondary manufacturing and, finally, the decision on the part of the parent companies as to when to produce in Canada rather than to import these products for competitive sale in this country. Export prospects, on the other hand, appear to be limited. Only a comparatively few companies have so far engaged in this type of activity. One reason for this is the considerable protection often accorded to these materials in other countries. Another is the comparatively late arrival on the Canadian scene of natural gas as a raw material for organic chemical production. A third and even more pertinent one is the relative slowness with which the more recent types of soft consumer goods industries have developed in this country as compared to the United States.

Mention has already been made of the fact that the basic inorganic chemicals are being sold principally to the nation's primary processing and export industries. These requirements, though not completely covered, are largely met from Canadian production. On the other hand, many of the larger volume organics used principally in the production of consumer goods are still largely imported. They serve a market which, due to its increasing complexity and ever changing character, is even more dependent upon fundamental and applied research. It is in this latter category that Canadian production is continuing to follow, sometimes after a decade or more, the manufacturing patterns which have been initiated elsewhere.

Competition from imports

Most of the heavy inorganic chemicals required by Canadian firms can be supplied from domestic sources. Trade figures, however, indicate that,

even today, the volume of heavy inorganics being brought into this country is about twice that exported. Indeed, purchases from elsewhere amount to approximately 40% of the nation's over-all requirements. Though a few products remain to be produced here, the principal reason for this apparent lack of self-sufficiency rests on a lack of regional diversification. Western Canada, for example, lacks a fully-rounded basic chemicals industry. Imports of heavy inorganics are therefore continuing at an appreciable rate.

A few examples may usefully be quoted. In 1955, when Canadian production of caustic soda amounted to some 224,000 tons, imports to the extent of 73,000 tons were still necessary. Chlorine imports amounted to 38,000 tons, though some 192,000 tons were produced here. The bulk of these foreign purchases were made by the booming British Columbia pulp and paper industry. Other heavy inorganic chemicals are also still being imported into British Columbia by low-cost barge transport, their total value last year being in the vicinity of $10 million. Thus, Canadian production of basic chemicals could have been increased by about one-eighth had it been able to service the British Columba market effectively in competition with producers in the neighbouring states of Oregon, Washington and California.

That this situation is changing is evidenced by the fact that one new plant for the production of caustic soda and chlorine, and another for the production of chlorates are now under construction in Vancouver. As a result of this expansion westward, imports with an annual value of between $5 million and $6 million will be replaced by Canadian production. More of this sort of thing is expected to happen as local markets grow and as the requirements, particularly of the primary industries, offer sufficient scope and continuity to support additional investments of this kind.

In so far as the heavy organic chemicals are concerned, regional diversification is of lesser importance. Transportation costs generally are less significant due to the usually higher unit price of the organics. Thus, Canadian production, once established, is often capable of competing with imported chemicals across the length and breadth of Canada. Imports, nevertheless, supply some 40% of the total domestic market. The chief reason for this heavy volume of foreign purchases lies in the incompleteness of the product range offered by Canadian industry. Moving rather belatedly into well-established lines, producers in this country have relied upon plants of their parent companies in the United States and elsewhere to pioneer and perhaps supply for many years Canadian requirements from their facilities abroad.

Part of the answer lies in the recent rise to prominence of petroleum and natural gas as a source of organic chemicals. The petrochemical in-

dustry began and grew to prominence in the United States over the last 25 years. Its real strength has only become apparent, commercially, since 1945. Its Canadian counterpart is much more recent in origin. Handicapped by a lack of cheap water transport, it is also less able to supply the entire Canadian market with the organics of lower unit value. Thus it may be many years before this country becomes relatively self-sufficient with regard to the production of the bulkier organic chemicals.

The acids, alkalies and salts industry in Canada is about one-seventeenth the size of its counterpart in the United States.[5] This is about the same relationship that the two industries bore to each other prior to World War II, although different growth rates have applied to each country in different time periods. Thus the Canadian industry grew at a faster rate from 1939 to 1947, while the United States' industry grew more quickly from 1947 to 1953.

Over the years a smaller percentage of production has been exported and a larger share has found markets at home. Thus despite no relative gain in size *vis-a-vis* the United States industry, Canada has become on net balance more self-sufficient in these products over the years. Some of these trends are confirmed by the following data on production, imports and exports of these basic chemicals for selected years:

Domestic Supply — Acids, Alkalies and Salts
(in millions of dollars)

	1929	1939	1943	1950	1953	1954	1955
(1) Gross value of production	28.0	23.1	78.4	87.5	127.3	142.0	175.3
(2) Imports	9.5	11.5	18.2	29.0	39.0	41.4	48.1
(3) Exports	10.9	8.7	16.0	11.3	13.2	12.4	16.4
(4) Domestic supply	26.6	25.9	80.6	105.2	153.1	171.0	207.0
(3) as % of (1)	38.9	37.7	20.4	12.9	10.4	8.7	9.4
(2) as % of (4)	35.7	44.4	22.6	27.6	25.5	24.2	23.2

Data on physical volume of output indicate that the industry has grown by over three times since prewar days or at an actual rate of 8% compounded annually.

Fertilizers

For many years, fertilizer production has been one of the most important of Canada's chemical industries.

From its inception, fertilizer production in Canada has been associated

[5]In general, census data for Canada and the United States indicate that the average plant in each country is of comparable size. However more production workers are employed per plant in Canada with a lower output per man being recorded.

with resource development. As hard rock mining and railway construction got under way, it became largely a by-product of the manufacture of dynamite, spent acid being used to treat local phosphate rock to produce a range of superphosphate fertilizers. The utilization of non-ferrous metal smelter fumes for the manufacture of sulphuric acid, the use of hydro-electric power for the fixation of nitrogen as cyanamide and ammonia and more recently by the manufacture of ammonia from natural gas, have made Canada one of the world's major fertilizer producing nations.

The principal chemical fertilizers made in Canada are ammonium nitrate, ammonium phosphate and ammonium sulphate. Together they account for more than half of the group's output. Next in importance are calcium cyanamide and superphosphate. Almost all the remaining output of the group consists of mixed fertilizers.

With value of output amounting to more than $93 million in 1955, the fertilizer group is second in importance only to acids, alkalies and salts in the industrial chemicals group, and accounts for about 8% of the production value of the chemicals and allied products industry. In 1954, the group produced 940 thousand tons of chemicals for fertilizers, and 668 thousand tons of mixed fertilizers. Total imports, largely to Eastern Canada, were 413 thousand tons, equal to about one-half of domestic sales. Total exports were 709 thousand tons, about three-quarters of fertilizer chemicals production.

An indication of the rate of growth of the group can be gained from a comparison with the United States fertilizer industry. In 1929, the United States produced 92 times as much fertilizer as did Canada; by 1939, the ratio had become 13 to one, while today the United States produces annually only about seven times as much as Canada. On the basis of this comparison with the United States, the fertilizer group is the leading Canadian chemical industry.

The main plant nutrients supplied by chemical fertilizers are nitrogen, phosphorus and potash. The principal raw materials are air, from which nitrogen is recovered; phosphate rock for phosphorus, and potassium chloride for potash. Despite the importance of Canada's fertilizer industry, neither phosphate rock nor potassium chloride at present comes from Canadian resources. Canadian fertilizer is produced to sell competitively on foreign markets not because of raw material availability but because of relatively cheap and plentiful natural gas, power and particularly low cost by-product sulphuric acid.

Of the $39 million worth of raw materials used by the fertilizer industry in 1954, over $6 million was imported phosphate rock and over $3.9 million was imported potassium salts. There should soon be major Canadian sources in Saskatchewan supplying potassium chloride for domestic and

foreign use. There are, however, no present indications that phosphate rock of Canadian origin can compete with United States supplies.

The cyanamide nitrogen fertilizer process was developed in Germany before World War I, and was introduced to Canada in 1909. The Haber process for ammonia synthesis became available after World War I, and in the early 1930's this process was used first in the important Canadian nitrogen industry. Since then synthetic ammonia fertilizer production has grown at a faster rate than all other type of nitrogenous fertilizer. In the manufacture of synthetic ammonia it is the availability of cheap hydrogen which dictates the location of the plant. More and more of the chemical industry is looking to the petroleum industry to supply hydrogen from natural gas, oil refinery by-product gas, or from fuel oil.

This has helped to "free up" the location of new fertilizer manufacturing facilities. With the advent of the large diameter pipeline and the super-tanker, the liquid fuels are becoming more transportable. Regional differences in energy and raw material costs are thereby reduced. Meanwhile, processes are being developed for the efficient conversion of natural gas and of residual oil into ammonia. Anhydrous ammonia is also being applied—and applied successfully—to the soil. Not only is this resulting in an over-all saving to the farmer but, by replacing the Haber process, it has tended to reduce the competitive advantage which Canada has enjoyed in respect to electric power costs.

Displacement of the naturally occuring nitrogenous fertilizers has not been acomplished painlessly. Initiated in part by Chile's export embargoes on sodium nitrate, there was a concerted rush in the years 1926-34 into synthetic production. In addition to becoming self-sufficient in this field, numerous countries found they had surplus capacity on their hands for a time. As a result, cartel arrangements grew up and international trade in these fertilizer materials was reduced.

World War II brought many changes. Various plants were destroyed, particularly in Western Europe. Meanwhile, on this continent, nitrogen making capacity was increased in the interest of producing explosives. The North American continent, as a result, changed from being a net importer to being a net exporter of these materials. Meanwhile, as a result of the agricultural lobby, bulk fertilizers began to be allowed into the United States market duty free.

Long-term trends in worldwide fertilizer use are reassuring. Even though assistance to the underdeveloped countries will not forever provide hard currency for fertilizer purchases, and even though the temporary deficiencies of starved soils are by now made up, more basic factors are increasing fertilizers demands. The most important of these are growing world population and rising world living standards. Government price support measures

for agricultural products are raising the farmers' cash income in many countries, and the support of soil conservation measures encourages more extensive fertilizer use.

Changing food tastes have also helped increase the demand for fertilizers. On this continent, per capita consumption of fruits, fresh vegetables and dairy products has been rising steadily. As a result, there has been a substantial rise in the quantity of fertilizer used in orchards, truck farms and grass lands. Twenty years ago, the one big North American user of fertilizer was cotton. Today, corn is in the lead, with small grains and vegetables ranking second and third. It is notable that pasture lands, which consumed only negligible amounts of fertilizer 20 years ago, are now using more fertilizer than all vegetables did before the war.

Numerous cases can be quoted in which the application of $1 worth of of fertilizer material results in increased yields of over $2 to $5 worth of farm products. Realizing this, agriculture, particularly in the western hemisphere, will increase its intensity of use. Though there are economic limits, it is frequently pointed out that in Western Europe, where land is comparatively scarce, farmers commonly employ between 10 to 25 times as much fertilizer as is current practice on this continent.

Canada's stature among world fertilizer producers has grown steadily, and in the 1940's she emerged as the world's second largest exporter of nitrogenous fertilizers. Export of fertilizer has been particularly advantageous to producers in helping smooth out the seasonal demand fluctuations which are characteristic of this market.

The further development of the Canadian fertilizer industry is dependent to some extent on increasing Canadian use of these materials, but to a much greater extent on comparatively free trade[6] in fertilizers and on the ability of Canadian producers to produce and sell in competition with United States and other foreign manufacturers. While local demands have had some influence on the regional concentration of this industry, the location of low-cost raw materials, the availability of power, and ease of access to export markets have been even more influential in the siting of new capacity. In the future the availability of natural gas and oil at reasonable prices will have a significant bearing upon the location of synthetic fertilizer plants in North America at large.

Half a dozen plants are now operating in western Canada. Three are owned and operated by the Consolidated Mining and Smelting Company;

[6]There is a 5% duty on fertilizer ingredients entering Canada for direct application to the soil. Amounts imported are small however.

two at Trail and Kimberley, British Columbia and one at Calgary, Alberta. Another metals producer, Sherritt Gordon Mines, produces ammonium sulphate at Edmonton. A new plant is now in operation at Medicine Hat, while still another is being discussed for Winnipeg. These facilities are conveniently situated to serve the needs of the Prairie Provinces, British Columbia and the United States Pacific northwest.

The situation in Eastern Canada is different. Nitrogenous fertilizers are being produced in Ontario by North American Cyanamid Limited, the sole producer of cyanamide in North America. There are at present three ammonia plants—one at Welland, one at Sarnia and another near Kingston. A fourth plant is in process of erection at Hamilton and is expected to come into production shortly. Much of this nitrogen will be consumed in Eastern Canada as fertilizer material, but a substantial quantity will also be available for export markets. In addition, there is a considerable production of super-phosphate fertilizer, manufactured from phosphate rock imported from Florida, and consumed in Eastern Canada fertilizer markets.

The fertilizer industry, while relatively prosperous, continues to be dependent on certain factors, the majority of which are beyond its own control. The Canadian and United States markets seem to be stable, growing and reasonably secure. The overseas markets are attractive, but all too often currency and exchange restrictions, sudden tariff changes or import quotas make them inaccessible. But agriculture in many parts of the world's underdeveloped areas offers tremendous long-term possibilities; for even in what are generally regarded as the more advanced countries, the application of synthetic plant foods is still far short of the rate at which minerals are being extracted from the soil. This is the main reason why Canada's overseas sales are expected to be well maintained. In the long run they may well expand, despite a continuing revival in European production and a continuation of United States exports of these important plant foods.

Primary Plastics

Plastics are becoming so plentiful in their various applications that today they are counted among the major industrial raw materials. In North America they now exceed the major non-ferrous metals in tonnage used. Also, since plastics are far lighter than metals, their consumption already exceeds that of aluminium in physical bulk. For a class of commodities of which all but a few were practically unknown 20 years ago, this is a truly remarkable record.[7]

But plastics are at once the pride and bane of many in the chemical industry. Properly used, they constitute one of the industry's greatest achievements; yet in their adaptation for commercial purposes they have

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[7] "Celluloid" was first produced commercially in 1867; "Bakelite" in 1909.

frequently been too little understood, oversold for a time, and only belatedly applied to the purposes which they could serve best.

The misuse of plastics has been partly attributable to inexperience in using new materials, partly to overoptimism on the part of producers and partly to a lack of discernment at the wholesale and retail levels. Consumer dissatisfaction with plastics often follows from their lack of familiarity with the new materials. Yet it is also true that the right plastic, used in the right place, is an incomparable material when judged on the twin bases of performance and price. It is for this reason that the plastics industry is fast becoming one of the most important groups within the Canadian chemical industry.

Plastics have passed through several stages of development. The early synthetic resins, like the early synthetic fibres, were modifications of natural products; hard rubber is an early example, as are the cellulosic plastics, cellulose nitrate ("celluloid"), acetate and others. Then, with a more complete understanding of polymerization, or the way in which small molecules link together to form big ones, came the truly synthetic plastics to fill 20th century needs.

There are two general classes of synthetic resins. First, the thermo-setting resins, which are formed by hot processes and in the forming process undergo chemical changes which cause them to be unaffected by high temperatures thereafter, unless they are heated to the charring point. The second class is the thermoplastic resins, which throughout their life will always become plastic, or will melt again, when their melting point is reached. Examples of the first class are phenol-formaldehyde, melamine-formaldehyde and urea-formaldehyde resins; they are strong, tough, light in colour and durable, with good electrical properties. Examples of thermo-plastics are the vinyls, acrylics, polystyrene, polyethylene and nylon.

There are now some 20 types of synthetic resins which are of major commercial importance. Of these, ten have been introduced or have attained major importance since the war, and more new types are coming along rapidly. Despite the newness of these developments, the range of plastics produced in Canada is remarkably wide—about ten of the major types are made in this country.

The many uses and possible applications of plastics are not surprising when one considers the wide range of physical qualities which they possess. They may be translucent, opaque or transparent. Some are rigid; some are flexible; while others have elastic qualities. There are plastics to satisfy various strength requirements—tensile, flexural, impact or pressure—depending only on the proper choice of materials. There are plastics which

are particularly resistant to moisture, corrosion, and moderate heat. Others are good insulators.

These differing physical characteristics do not altogether explain the adaptability of the plastics. They may be formed into almost any desired shape. Some plastics may be moulded or cast, such as telephone hand sets and radio cabinets. Sheets can be formed into airplane cockpit enclosures or instrument panel faces. In the form of film, plastics can be used for packaging or display purposes, upholstery or wearing apparel. The production of many laminated objects, including safety glass and metal aircraft panels, are made possible through the use of plastic bonded resins. Table and kitchen and bathroom wall panels are further examples. They may be used to coat or impregnate other materials, appearing as refrigerator and automobile enamels, seat coverings, etc. As adhesives or bonding agents, plastics are already being consumed in large quantities by Canada's plywood industry. In another form they appear as fibres fine enough for the sheerest hosiery, and coarse enough to replace wire window screening.

Obviously, no one material can have all the qualities necessary to fill all these roles. But the plastics are not one, but many. They are a family group, and a very versatile family too. Not only has their price been steadily declining relative to that of other industrial materials, but their ease of fabrication, lightness, durability and attractiveness cause them to be preferred in industry. They are already supplementing metal, wood, stone, glass, leather, paper and fabrics with qualities which these latter materials do not have when they are used alone.

The Canadian primary plastics group is young, but already important; it is the fourth largest in the industrial chemicals group, exceeded only by acids, alkalies and salts, fertilizers and explosives. It is growing vigorously; between 1954 and 1955 the chemical and allied products industry increased its value of output by 12%, while the primary plastics group grew 25%, or more than twice as rapidly.

The primary plastics group, for which data are reported by the D.B.S., is not closely representative, however, of the Canadian synthetic resin industry. Materials such as "Cellophane" and other transparent cellulose films make up a portion of the value product of the group, and sodium carboxymethyl cellulose, not usually considered a resin, is also included. While the gross value of primary plastics products in 1954 was $50.4 million, true synthetic resins probably made up only about three-quarters of this total. A special D.B.S. compilation collects figures for the synthetic resins made in the primary plastics group and in other groups—alkyd resins made in the paint industry, vinyl resins made in the acids, alkalies and salts group, and so on. This shows that the total value of synthetic resins made in Canada in 1954 was $36.6 million. Production for 1955 was greater to the extent of some 35%. Further data are presented in this table.

Synthetic Resins, Value in $ Millions

Year	Domestic production	Imports	Exports	Apparent supply
1935	1.0[a]	1.8	—	2.8
1940	2.0[a]	2.8	1.1	3.7
1945	6.8	9.1	1.4	14.5
1950	19.1	18.2	6.9	30.4
1951	23.1	22.9	10.3	35.7
1952	19.1	21.8	5.3	37.0
1953	26.3	28.1	8.5	50.0
1954	36.6	35.9	11.2	61.3
1955	49.3	41.6	13.1	77.8

[a]Estimated.

The table clearly shows the mushrooming growth of the plastics industry. It shows, too, that demand has been increasing at about the same rate as supply; despite the rapid increase in plastics production, imports have very nearly equalled production in all postwar years. Finally, the export column shows that Canadian plastics are well known in foreign markets, though for many reasons this demand is a fluctuating and rather undependable one.

Canada, the country where one major synthetic resin type—the vinyl acetals—was originated (by Shawinigan Chemicals Limited), is today the world's sixth largest producer of plastics. On balance she supplies about two-thirds of her own needs, and exports many plastics in the face of keen competition from United States and European producers.

But from any point of view, the industry still has much growing to do, and its future growth prospects are excellent. A comparison with the United States shows that the Canadian group is only one-thirtieth the size of the U.S. plastics industry; and, of course, that it is far less developed in respect to range of products. There is also the fact that Canadian imports nearly equal Canadian production of plastics; theoretically, if not in practice, the industry could be doubled tomorrow and still find markets for all its products.

For several years after the war, production in the industry was hampered by a shortage of raw materials. Here, as in the United States, the output of coal tar products has been unable to keep abreast of the needs of the primary producers. This is one of the reasons why the petroleum and natural gas resources of Alberta have been attracting so much attention.

Rising petrochemical production bodes well for the plastics industry. Within recent years Canada has become virtually self-sufficient in phenol, formaldehyde and polyethylene. Production of styrene monomer and polystyrene have been greatly expanded.

In spite of the long list of new or expanded projects, there are several

chemicals used in the plastics industry for which production facilities are not at present contemplated, or at least not announced publicly for this country. Among these are such things as melamine for resins and finishes, and resorcinol for adhesives.

Although Canadian resources in cellulose and nitric acid have existed for many years, no facilities yet exist here for the manufacture of nitrocellulose moulding powder. Nor do we make cellulose acetate moulding powder, although Canada has for a long time been one of the world's largest exporters of cellulose and of acetic acid. Similarly, Canada has one of the world's largest plants for the manufacture of calcium cyanamide and this continent's only plant for turning out dicyandiamide, which serves as the basic raw material for melamine resins. Obviously it is only a matter of time before these and other plastics such as nylon moulding powder are made here in sufficient quantities to meet most of the nation's needs.

Synthetic Fibres[8]

There are two distinct classes of synthetic fibres and they can be taken as representative of two different stages in the development of modern textile technology. One is the chemical cellulose fibres. Then there are the newer, fully manufactured synthetics. Built up from hydrocarbon sources such as coal tar and petroleum, the latter are even greater in number and variety than the former.

The chemical cellulose fibres, of which the most important are viscose rayon and cellulose acetate, represent chemical modification of natural materials. Given the long chemical molecule of cellulose as present in wood, the chemist at the end of the last century devised methods for dissolving and then regenerating the fibre in a form suitable for textile use. Rayon and acetate are therefore fibres which have been modified, rather than created, by chemistry.

The newer synthetic fibres are not just modifications of the fibres found in nature. They are built from small individual chemical molecules in the same way that a chain is forged from individual links. Also being the products of controlled chemical synthesis, they are completely new materials which can be tailored, in effect, to demand. Subsequently blended with

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[8]The synthetic fibre industry in Canada is classed as part of the textiles, rather than the chemical and allied products industry, but it has been included in our over-all figures for the industrial chemicals groups, since it is as intimately associated with basic chemicals manufacture as are primary plastics and synthetic rubber. Production of several materials for their manufacture is actually included in the acids, alkalies and salts group; this is true of nylon intermediates and, in part, of cellulose acetate. Value of production of the other fibres is included in the total value figure for the output of the industrial chemicals group.

other fibres, or used entirely on their own, they thus are able to impart desirable properties to a whole range of products.

The story of synthetic cellulosic fibres in Canada begins in 1916, when acetate dopes for aircraft fabric and cordite were first made at Shawinigan Falls. The existence of this capacity was a major factor in encouraging the establishment of an acetate fibre plant at Drummondville, Quebec, in 1928. Beginning in 1925, viscose rayon was produced at a plant in Cornwall, Ontario. As this process consumes large quantities of caustic soda and carbon disulphide, it was responsible for the erection in Cornwall of plants to produce these chemicals.

Nylon yarn, the first of the true synthetics, began to be produced in Canada at Kingston in 1942, in a plant erected with highest wartime priorities because of the urgent need for nylon parachute cord. At first, nylon flake was brought in from the United States to make yarn in this plant. Later, the intermediate chemicals were imported and combined at Kingston to form nylon salt. The latest step has been the erection at Maitland, Ontario, of a multi-million dollar plant to make hexamethylene diamine and adipic acid, the two nylon intermediates.

More recently, a major petrochemical and synthetic fibre plant has come into production near Edmonton. While it produces a wide range of synthetic organic chemicals from petroleum fractions, the main product of the operation is cellulose acetate fibre. The location of this plant was influenced by various factors. Cellulose, or alpha wood pulp for acetate manufacture, could be produced in great quantity and highest quality in British Columbia. Most of it must travel east to market, either in Canada or in the United States. The logical place for it to be transformed into acetate yarn was Alberta. There acetic acid derived from natural gas is combined with the cellulose, and the acetate is formed. While acetate yarns are produced in the plant, the cellulose acetate flake may also be shipped without further processing, either to other manufacturing locations in Canada or to export markets.

The range of synthetics manufactured in Canada is rapidly becoming complete. A $20 million "Terylene" plant near Kingston is now in production, and an "Orlon" plant is scheduled for erection at Maitland, Ontario.

In 1926, rayon and acetate accounted for less than 2% of total fibre consumption in Canada; today they provide more than 25 % of the fibres used for Canadian textiles manufacture. Nylon in 1952 stood about where rayon stood in 1926. Since then nylon and the other synthetics have increased in relative importance, though it may be many years before they achieve a volume commensurate with rayon and acetate.

As new plants have been constructed, Canadian synthetic fibre requirements have been met increasingly from domestic sources. This is seen in

the following table, which shows the relative importance of production imports and exports in recent years.

Canadian Production and Trade in Synthetic Yarns and Fibres
(in millions of pounds)

Year	Domestic production	Imports	Exports	Available supplies
1938	13.4	2.6	—	16.0
1946	23.6	17.4	0.2	40.8
1948	34.6	21.1	4.1	51.6
1950	60.4	17.4	5.3	72.5
1951	60.4	27.8	2.0	86.2
1952	72.3	19.7	1.9	90.1
1953	71.4	19.9	1.7	89.6
1954	72.2	12.7	5.8	84.1
1955	83.8	19.3	2.5	100.6

The synthetics have not only a number of new qualities that make them attractive to the consumer, but advantages that make them appeal strongly to the textile manufacturer. They possess uniformity of fineness and staple length not found in natural fibres. The waste involved in working them up into textile goods is comparatively small, and many times, in cases where the manufacturer previously found that he had to adjust his operations to his fibre, he now finds the newer fibres more adaptable. Because the supply of synthetics is not tied in any way to food or crop production, the textile manufacturer has no fear of fluctuating supplies, and price fluctuations, when they do take place, are much less severe than in the case of natural fibres.

The use of rayon and acetate has risen so rapidly because these fibres have been widely used both as complements to and substitutes for natural fibres. These fibres, like the other synthetics, are produced both as filament yarns and as staple fibre. Because of this, they can be used in making a complete range of cloth types. In recent years, rayon and acetate have become more and more popular for summer wear, both in fabrics for women's clothes and in summer suitings for men. In the field of industrial use, with the increase in production of high-tenacity rayon, rayon tire cord has largely displaced cotton because of its superior heat resistance.

While acetate has been gaining relative to rayon, it would be wrong to conclude that one is likely to drive the other from the market. The fibres are complementary and are used increasingly in combinations, particularly in staple fibre form. The use of rayon is growing in the industrial field, and acetate is receiving more and more attention as a versatile fibre for fashion fabrics.

Nylon is already well established both in knitting and weaving applications. Its strength, abrasion resistance and elasticity combine to give it

advantages over most other known fibres. On the other hand the polyesters ("Terylene", "Dacron") have found greater acceptance in fabrics like lightweight, worsted type suitings. The acrylics (like "Orlon") have a softness which makes them excellent for blankets, overcoats and sweaters, and a strength, acid resistance and resistance to sunlight which suit them for use in fabrics ranging from curtain materials to tent cloth, awnings and other heavy outdoor textiles. All the later synthetics exhibit the water-impermeability, strength and resistance to deterioration from natural agents or chemicals that fit them for an unending number of industrial uses, in some of which they will do jobs that no textiles have been able to do before.

In time more and more new fibres will be chemically tailored to have exactly the qualities desired. The best future prospect for synthetics lies not in the fact that any one is likely to be superior to a natural fibre in all respects, but that there can be created a range of synthetics. each of which is superior to some natural fibre for a certain use.

The situation of wool versus synthetics typifies this trend. Wool is an extremely versatile fibre, and no one synthetic attempts to compete with it in all its uses. But nylon has replaced part of the wool previously used in men's stockings, rugs, and upholstery materials. Acrylics are used to make wool-like overcoats, blankets and sweaters, and polyesters can already compete in the field of worsted suitings.

It is therefore unlikely that synthetics will replace wool and cotton in their entirety. Instead the synthetics and the natural fibres may be employed more and more together and in complementary fashion. The very methods which have proven so successful in one case are already being adapted to the other. Chemistry and chemical processes are, in other words, being employed wholeheartedly by the older branches of the textile industries as well.

Coal Tar Distillation Products

At one time the production of organic chemicals was based almost entirely on coal. More recently, with the increasing availability of oil and natural gas, petrochemicals have taken over much of this field. This has been true particularly in Canada, where the use of coking coal is being confined more and more to metallurgical works, and the sale of by-products is profitable only for the larger and more highly integrated steel mills.

Coal tar chemicals, first produced in Britain, later became the basis of Germany's synthetic organic chemical industry—the world's most advanced, at least up until the end of World War I. Subsequently, defence considerations led to the erection of tariff barriers and a consequent reduction in international trade in these materials.

Since the 1920's the growth of organic chemical synthesis from petroleum and natural gas has been remarkable. First introduced on this continent, it has reached its greatest flowering in the United States. Even in Western Europe, where coal is still the basis of many a heavy industry, petrochemicals are now making considerable headway. Because the coal tar products industry failed to become well established in Canada in its days of greatest prosperity, it now suffers a double handicap. As far as raw materials are concerned, other more manageable[8] and abundant sources are at hand. The technology employed in liquid fuels is well advanced. Also, the oil industry, with strong financial backing and considerable experience in chemical methods of processing, is now turning its attention to this particular field of endeavour.

Natural gas, meanwhile, is putting an end to the manufactured gas business. One after another, the distributing utilities are closing down their coke ovens, thus reducing the domestic supply of raw coal tar products. Only the steel industry (and, possibly, one or two other metallurgical operations in the future) are likely to be moving in the opposite direction. Needing coke, they will sell its by-products wherever they can. Located as they are, close to other industry, it will frequently pay them to convert much of their surplus gas and coal tar residues into chemicals.

But, on balance, the "aromatic" or cyclic organic compounds which once came exclusively from coal tar can and will be provided by the natural gas purification plants, from the oil refineries in the principal industrial centres and from petrochemical operations in their own right. Since the majority of these allied industries (*i.e.* natural gas production, oil refinery output and basic chemical production) are growing at rates faster than that of steel, the complex synthetic organics are likely to come increasingly from these newer, inherently simpler and more widely distributed sources of supply.

In Canada, the production of coal tar products has lagged well behind that of the major industrial countries. What has been accomplished has been limited essentially to the first phase—that of separating the coal tar residues to yield such organic compounds as pitch, creosote oils and refined tars. With a half dozen exceptions, the second (or genuinely chemical phase) has never made much headway in Canada. The limited size of the Canadian market has been one of the stumbling blocks. Comparatively little protection, a lack of basic research, and stiff competition from foreign producers have been others. As a result, most dye-stuffs and such pharmaceuticals as are typical of the more highly manufactured coal tar distillation products are purchased elsewhere, only to be mixed, packaged and distributed in this country.

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[8]Oil is much simpler in its chemical structure and natural gas very much simpler than coal, which is inherently one of nature's most complex substances.

The Canadian coal tar industry was built up for a substantially different reason; that of meeting the needs of the nation's producers of electro-chemical and electro-metallurgical products. The latter require electrodes of large size, and certain coal tar pitches have been found to be the best binding materials whether for preformed electrodes or the continuous Soderberg type. In Canada a continuing market is provided by the electro-chemical industries making aluminum, calcium carbide, "Carborundum", ferro-alloys, caustic soda and chlorine.

Plants for the refining of coal tar are relatively simple in construction and they are located at various places across the country near to raw materials supply from by-product coke installations. Now that these are being progressively closed down with the arrival of natural gas, there will be an increasing concentration in, or close to, the major centres of steel or other primary metals production.

The structure of the Canadian industry is comparatively simple. Eleven plants were in operation in 1955; of these, five were owned by one major producer, four were owned by a second firm, and two other companies each operated single plants. Both major producers are also prominent in the roofing and building products fields.

Among the purely chemical products of the industry are phenol, cresol and cresylic acid. In one plant cresol is further refined to ortho-cresol and meta-para-cresol. In two plants phthalic anhydride is also manufactured from naphthalene. There is one small producer of nitrobenzene and aniline for rubber chemicals.

Phenol is employed in a variety of ways. It is the basis for certain synthetic resins, for wood preservatives and can be used as a starting point for making certain fine organic compounds such as aspirin. It is well known as a disinfectant under the commercial name, carbolic acid. Total demand in this case has had a tendency to run ahead of supply. Phenol produced by chemical synthesis from petroleum raw material has therefore been necessary. As in the United States, capacity for this purpose has also been installed in Canada.

Other constituents of the light oil fractions are benzene, toluene and xylenes. Used extensively as solvents, for blending purposes in the manufacture of gasoline and as chemical intermediates in the manufacture of synthetic rubber, they find a ready market in this country. In their case, production from petrochemical sources commenced in Canada only after 1954.

The cruder materials move quite freely in international trade. Unimpeded by duties, pitch, tar and tar oils move both ways across the Canada-U.S. border. This is in striking contrast with the one-way movement into

Canada of the much more highly manufactured end-products such as the coal-based drugs and dye-stuffs. Various countries participating in this trade from behind comparatively high tariff barriers include Switzerland, Western Germany, the United Kingdom and the United States. Occasional shipments have also been received from France, the Netherlands, Belgium, Italy and Norway.

In time, some further production of coal tar intermediates and specialized end-products may get under way in Canada. Now nitrobenzene and aniline, the basis of the coal tar dyes, are already being made in this country, though principally for rubber compounding. A few other products may be added from time to time as the technology in this area develops and local market considerations permit.

The prospects for a considerable rounding out and development of this area of chemical production in Canada are, however, uncertain. Should the production of synthetic liquid fuels from bituminous coal and lignite get under way in any volume in the United States, this will result in a lasting surplus of primary and intermediate chemicals of the coal tar variety. Improved yields are possible in the steel and other metallurgical industries. And the oil refinery and other petrochemical sources will doubtless continue to produce a number of these compounds. Faced with this sort of competition from producers both outside and inside the country and, at the same time, with the need to strike a neat balance between production and domestic market requirements for these various organics, the Canadian industry may find it difficult to duplicate in number and variety the coal tar chemicals presently being produced in the more highly protected economies of the United States and Western Europe.

The following table, though it relates only to the primary coal tar products, indicates both the rate of growth of the Canadian market and the degree of self-sufficiency which has been achieved in this particular phase of chemical production.

Canadian Production and Trade in Primary Coal Tar Products, 1939-55

(in millions of current dollars)

Year	Domestic production	Imports	Exports	Available supply	Imports as % of available supply
1939	3.6	0.3	0.5	3.4	8.8
1943	6.5	0.8	0.6	6.7	11.9
1950	10.0	2.0	0.8	11.2	17.9
1953	13.6	3.2	1.0	15.8	20.3
1954	12.9	2.7	0.4	15.2	17.8
1955	12.8	3.4	0.5	15.7	21.7

Compressed Gases

The Canadian industry produces such widely used industrial gases as oxygen, acetylene and carbon dioxide. Oxygen is the most important. It accounts for nearly half the value of output of these plants, acetylene for about one-third, and carbon dioxide for less than one-sixth. The first two products are used principally for welding and in the metal working trades while carbon dioxide is employed in gaseous form by the beverage manufacturers and as "dry ice" for refrigeration.

Over the past decade oxygen production has increased by approximately 80%, that of acetylene by about 50%.[9]

Major firms in the group are three, two specializing in acetylene and oxygen and one manufacturing principally carbon dioxide. They operate 40 of the 46 plants, the remainder being controlled by a host of smaller companies. Generally, the plants are small, employing several dozen workers apiece. Most Canadian cities from St. John's, Newfoundland to Vancouver boast one or more of these operations. Their equipment is simple and their major raw materials are three in number; calcium carbide (purchased from other chemical firms), water, and air. Minor products produced jointly or incidentally to other chemical operations are ammonia, nitrous oxide, nitrogen, hydrogen and argon.

There is little international trade or, for that matter, inter-regional trade in the industrial gases. They are almost always produced in or close to the consuming centres in which they are required. Technological developments which are possible in the steel and other metallurgical industries may add considerably to the demand for oxygen. Acetylene requirements, on the other hand, may be determined much more by the level of construction activity; the demand for carbon dioxide by developments in food processing and distribution. From time to time new products may be added to the list. For example, helium may one day be recovered as a by-product of natural gas production. These possibilities, together with a minimum of competition from imports, should ensure a substantial rate of growth in this comparatively small and yet highly specialized area of chemical production.

Miscellaneous Chemicals

A variety of industrial chemicals, other than those already discussed, are in quantity production in this country. They include explosives, synthetic rubber, pesticides, colours and pigments, wood distillation products, and the like. In both value and volume terms, explosives and synthetic rubber production are by far the most important; the others much less so. They will, therefore, be discussed in that order.

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[9]While production statistics for carbon dioxide are not available, data on consumption indicate an increase of about 25% over the past five years.

Explosives

The production of explosives, both commercial and military, has probably stimulated Canadian chemical production more than any other single factor, with the possible exception of resource development.

Commercial requirements, while they have been relatively small, have expanded more or less continuously. War needs on the other hand have mushroomed to unprecedented proportions twice in the past half century. Korea also caused a flurry of new construction. Left in their wake has been a great deal of manufacturing capacity, much of which has been converted to serve Canada's civilian economy.

Historically, defence demands, while impressive, have been of relatively short duration. In World War I, the output of Canada's chemical munitions industry was expanded approximately three times over in the years between 1915 and 1918. Plants were built to manufacture gun cotton, cordite, ammonium nitrate and TNT. But with the exception of nitroglycerin, which continued to be used in the form of dynamite, the manufacture of most high explosive ingredients was discontinued as soon as hostilities ceased.

With the outbreak of war again in 1939, chemical munitions manufacture again had to start from modest beginnings. This time the flashless propellant containing picrite and the super high explosive RDX were also slated for manufacture in large quantities in this country, the latter to be mass produced for the first time in the world in Canada. They, together with many other products which ultimately appeared in the form of ammunition of all kinds, were made in over 30 entirely new plants capitalized at over $100 million. In value of output they amounted to well over half of the total production of the rest of the chemical industry by 1943. As to variety, they were not only adequate to meet almost all of the chemicals and explosives requirements of the Canadian armed forces but to allow for considerable export as well.

The contribution of Canada's chemical industry during World War II was not confined as before to the mass production of products developed elsewhere. This time, Canadian research scientists and engineers were largely responsible for the introduction of new processes like that which made the large-scale manufacture of RDX possible in North America. They also devised new methods for making TNT, replaced cotton with wood cellulose for the manufacture of propellants, and built the allies' largest nitroguanidine plant at Welland, Ontario.

Since 1945, relatively little production has been carried on, although Canada has kept well informed in the field of military explosives. Korea caused reactivation of facilities to make World War II types, but modest enlargement of these facilities is still needed before it will be possible to manufacture the newer types required. Canada's unique position with regard to electric power enabled her again to produce picrite for export to

NATO countries. Canada also exports hexachlorethane which is of considerable importance as an ingredient of smoke ammunition. Post-Korean demands, by and large, have been modest in volume and insufficient to warrant full-out operation of the facilities concerned.

No completely new plants have been required for military explosives and chemicals. The only ones to be built in Canada in recent years were designed to turn out commercial explosives. One located near Calgary employs for the first time in North America a continuous process for the nitration of glycerine, and will supply the oil and gas exploration and other mining industries presently active in eastern Britsh Columbia, Alberta and Saskatchewan. Another commercial explosives plant is being built at North Bay, Ontario. Together with the older plants, it raises to eight the number of establishments making commercial explosives in this country.

Should the international situation continue more or less as at present, further activities in this sector of Canada's chemical industry will be governed by technological developments as they gradually emerge. All-out war, on the other hand, would again call for the rapid erection of additional facilities on a larger scale. Demanding even closer liaison and programme integration with that of the United States, the emphasis in Canada would probably be placed on the manufacture of explosives and other defence chemicals for which this country's resources or industrial know-how are best suited.

Synthetic rubber

The countries which pioneered in manufacturing synthetic rubber were Germany and Russia. Before World War II, Russia was the world's largest producer, Germany was second, and the United States was third with small production of special rubbers such as Neoprene and Thiokol. Germany was able to become almost independent of natural rubber during the war period, and Russia has continued to expand its manufacture of synthetic rubber considerably up to the present time.

In 1941, when Indonesia, Malaya and other Far Eastern countries were occupied by the Japanese, rubber supplies to the western world were cut off at a time when there was less than one year's supply in inventory. A major co-operative programme between government and the petroleum and chemical industries in the United States and Canada came into being, for the purpose of creating a synthetic rubber industry to bridge this gap in supply. The results represent the chemical industry's greatest wartime achievement, exceeded only by the atomic energy and radar programmes in magnitude and effect.

In the short period of two years, facilities were designed and constructed for the manufacture annually of 900,000 short tons of various synthetic rubbers. The most complete and fully integrated of these plants was that of

Polymer Corporation Limited, originally designed for production of nearly 45,000 short tons per year, which was constructed adjacent to the petroleum refinery of Imperial Oil Limited at Sarnia, Ontario. By 1945, the installation was able to satisfy all Canadian requirements for synthetic rubber and to provide substantial quantities for export to the United States and Europe.

Trends in the world consumption of rubber are reflected in the following data for selected years since 1935.

Estimated World Consumption of New Rubber in Thousands of Short Tons

Year	1935-39 av.	1940	1945	1950	1951	1952	1953	1954	1955
Natural	964	1,456	288	2,016	1,674	1,625	1,809	1,932	2,120
Synthetic	8	43	866	580	913	991	978	823	1,180

At the end of the war, natural rubber once more became available, often at prices as much as 10% below those of synthetic rubber. This fact, and certain advantages in properties, resulted by 1949 in natural rubber regaining over 50% of the North American market and almost all of the markets elsewhere. Many of the U.S. government plants were shut down. In Canada, Polymer Corporation Limited was able, as an integrated plant, to continue an economic operation in competition with natural rubber and succeeded in developing a thriving export business.

Concurrent with increased competition from natural rubber, the synthetic rubber industry in the United States and Canada conducted extensive research and development to improve quality and reduce production costs.

Improvements in Butyl rubber, to which Polymer Corporation made a major contribution, gave improved processability, better low-temperature performance, lower cost compounds and a wide variety of uses in insulation, auto fittings, waterproofed goods, as well as the original application in inner tubes.

Improvements in the original general purpose butadiene-styrene rubbers were accomplished, following German wartime research data, by conducting polymerization at lower temperatures. The so-called cold rubber has improved tensile properties and outstanding abrasion resistance and is steadily displacing natural rubber for use in tire treads. A further development, which Polymer Corporation was the first to reduce to commercial practice, consisted of using the cold process to produce a very tough rubber, which could accommodate up to 40% of its own weight of inexpensive oils and still retain superior abrasion resistance. In 1955, more than 72% of all butadiene-styrene rubber was made by the "cold" process.

Manufacture was expanded of special types of synthetic rubber, such as oil-resistant rubber for hose and fuel cells, leather-like materials for shoe

soling and floor tiles, film forming emulsions for use in paints, high solids lattices for manufacture of foam sponge.

Important as these discoveries were, their significance was not immediately apreciated in other industries. However, with the outbreak of war in Korea, a marked rise in the price of natural rubber occurred, and synthetic rubbers suddenly became in great demand. Within 12 months, synthetic rubber production in the United States was increased 80% by reactivating idle plants. In Canada, where Polymer Corporation was already in full production, new facilities were installed which raised production a further 15%. This flood of new rubber served to arrest the rise in price of natural rubber, and eventually to stabilize it near the pre-Korean war levels.

Without synthetic rubber, the world would now be short by nearly one million tons per year, which would necessitate the rationing of automobiles and gasoline and restriction on travel. The output of natural rubber cannot keep pace with the steady growth in world demand, which has doubled since the war and continues to rise. In spite of replanting programmes, such as advocated by Malaya, maintenance of supplies of natural rubber at present levels is all that can be hoped for, giving due regard to the political uncertainties and rising costs in the Far East. Future growth in requirements for rubber must therefore be met by expansion of synthetic rubber production.

One of the most important factors contributing to the economic producion of synthetic rubber is a plentiful supply of low cost hydrocarbons, such as butanes, butylenes, ethylene and benzene, from which the base stocks of butadiene, styrene, isobutylene and isoprene can be manufactured. For this reason, the major area of supply and expansion will be Canada and the United States for some time to come. Plans have been announced for the production of synthetic rubber in other countries and it seems probable that by 1958-60, the manufacture of general-purpose type will be established in the United Kingdom, France, Italy, and Western Germany. In all, they involve the construction of some 175,000 tons of new capacity. Industry sources none-the-less suggest that, even when these plants are operating in 1958, a shortage of at least 75,000 tons may still exist.

To the extent that new plants will meet requirements for synthetic rubber in these countries and for export, purchases from Canada and the United States will be diminished. However, the growing demand in home markets, combined with an even greater rate of growth in countries such as Australia, South Africa, India and South America, leaves no doubt that production in Canada and the United States will be taxed and must be expanded steadily for many years to come.

The relative importance of production, consumption and export of synthetic rubber and the importation and use of natural rubber in Canada is shown in the following table for selected years.

Quantity in Thousands of Short Tons

Year	Natural rubber		Synthetic rubber			Natural plus synthetic
	Imports	Consumption	Production	Consumption	Export	Consumption
1940	58.9	41.4	nil	nil	nil	41.4
1943	9.3	6.6	51.2	40.3	10.9	46.9
1950	51.8	51.7	67.7	25.3	42.4	77.0
1951	53.8	49.7	69.7	29.6	40.1	79.3
1952	40.5	37.5	82.8	37.6	45.2	75.1
1953	40.7	42.0	90.1	40.2	49.9	82.2
1954	47.8	46.6	97.0	33.7	63.3	80.3
1955	51.2	50.5	114.5	45.0	69.5	95.5

Polymer Corporation Limited[10] is now actively studying means of obtaining increased supplies of basic raw materials on which to build sound future growth. Of particular interest are the low cost hydrocarbons arising from the oil and gas developments in Western Canada, as well as the increasing volume of by-products becoming available from the expanding petroleum refining industry in Sarnia.

Other miscellaneous chemicals

Some 252 additional plants in this sub-group, employing on the average little more than 35 persons per plant, produce a myriad of chemical products. In 1955 some $70 million worth of these chemicals were shipped to both industrial and consumer markets, about the same as in 1954.

Detailed statistics are available for the latter year. Some of the more important classes of products are as follows:

Product class	1954 production $ millions
Automobile chemicals	4.6
Boiler chemicals	2.7
Cleaning preparations	2.7
Insecticide and weed killers	7.5
Matches	4.8
Textile and leather finishes	3.3
Dry colours and pigments	4.6
Oils, sulphonated and other	2.1

Many other products selling for less than a million dollars a year include disinfectants, deodorants, embalming fluid, floor waxes, food colours, welding compounds, fluxes and rust preventives.

[10]In 1955, Polymer Corporation Limited employed approximately 2,500 people in all phases of its operation and sold over $65 million worth of synthetic rubber and petroleum derivatives.

Some of these products are dependent on consumer demand for further growth and others on industrial expansion. In most cases they are made in small plants located near the major markets for their products.

Consumer and Allied Chemicals

General

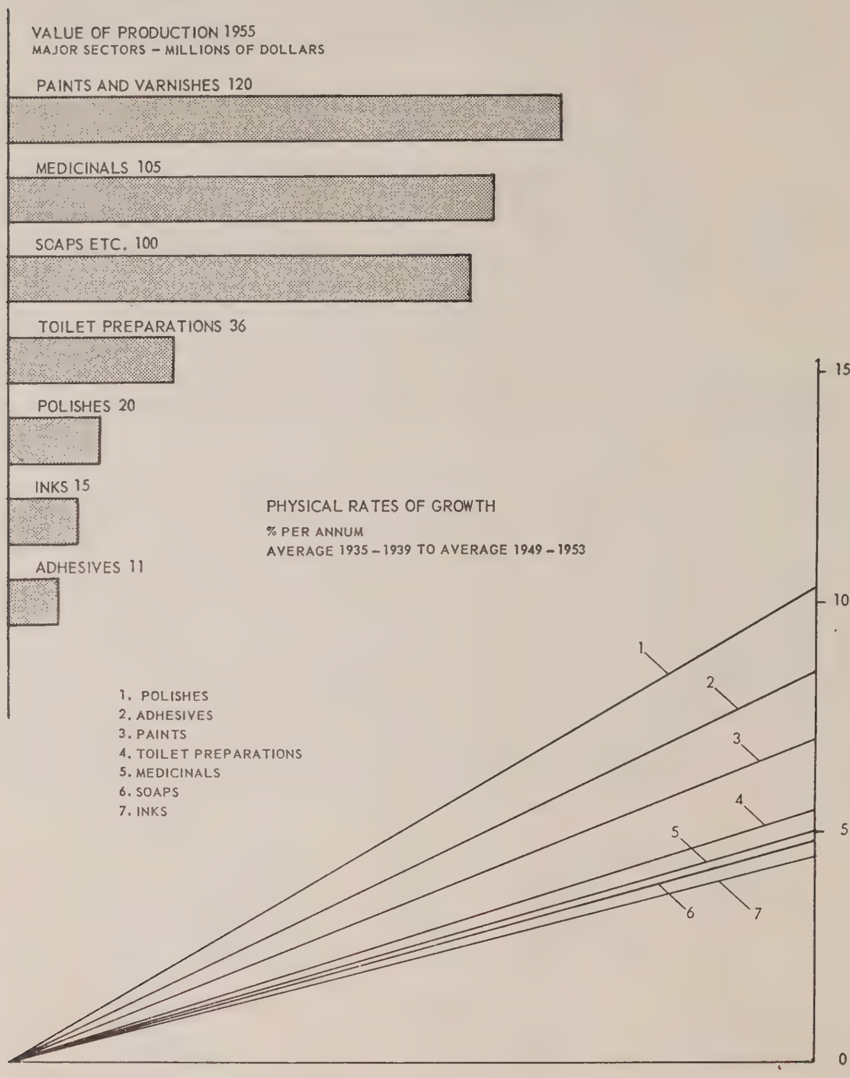
The majority of the industrial chemicals, as we have seen, are sold to other industrial users. Yet there is a host of other commodities which, in a general way, are also referred to as chemical products. Made from chemicals, but not necessarily employing chemical processes, they are manufactured in a variety of plants which, for want of a better description, are referred to as the allied chemicals group. Since their output also enters more directly into consumption, the paints, drugs, soaps, adhesives and oils which they manufacture will hereafter be described as consumer and allied chemicals.

In employment and output terms this heterogenous array of plants is also of some consequence. Collectively, the firms classified under the various sub-groupings provide work for some 22,000 employees or about 40% of the labour force of the entire chemical industry. Currently the annual selling value of its products is approaching $500 million or about two-fifths of the total value of chemical production in Canada. Three, at least, are worthy of separate mention: the paint industry, plants making medicinals and pharmaceuticals, and establishments making soaps and washing compounds. Each boasts a yearly gross value of products greater than that of Canada's output of fertilizers, plastics or synthetic rubber. (See chart entitled Production of Consumer and Allied Chemicals—Canada, 1955.)

Composition of the Consumer and Allied Products Group

Sub-groups	Number of plants		Number of employees		Selling value of products $ millions		%	
	1953	1955	1953	1955	1953	1955	1953	1955
Paints, varnishes and lacquers	122	123	5,887	5,975	113.3	120.3	26.8	26.0
Medicinals and pharmaceuticals	217	208	7,492	7,494	93.6	104.9	22.1	22.7
Soaps and washing compounds	141	137	3,824	3,770	89.3	100.4	21.1	21.7
Toilet preparations	94	96	1,955	2,145	30.4	36.1	7.2	7.8
Polishes and dressings	49	45	845	757	17.2	19.6	4.1	4.2
Inks	33	35	891	960	12.8	14.7	3.0	3.2
Adhesives	29	30	707	572	12.1	10.7	2.9	2.3
Vegetable oils	13	12	675	683	50.8	50.8	12.0	11.0
All other	—	—	—	—	3.7	4.9	0.8	1.1
Total	698	686	22,276	22,356	423.2	462.4	100.0	100.0

PRODUCTION OF CONSUMER AND ALLIED CHEMICALS – CANADA



On the other hand the average factory is much smaller in size. Canada's paint manufacturers, while selling a smaller volume of output than firms making basic chemicals, operate a total of 123 plants. Meanwhile factories making the larger volume industrial acids, alkalies and salts boast only 41 establishments. Again, Canada's output of primary fertilizers is comparable in value to that of soaps and washing compounds. The soap industry, however, operates 137 separate plants, companies making chemical fertilizers only 39.

Other lines of demarcation can be drawn. But perhaps the most striking is the extent to which Canada is self-sufficient in the consumer and allied chemical products. All but about 10% to 15% of the paints, drugs, soaps, inks, etc., marketed in this country come from domestic sources.[11] Imports, consequently, account for only a small fraction of domestic requirements. Exports, meanwhile, are negligible relative to total Canadian production. This is in marked contrast to the situation which still prevails in respect to many industrial chemicals. Though the latter are made in much larger quantities by plants whose efficiency has more frequently been put to the test of export competition, they only supply about 65% to 75% of Canadian requirements.

The following table, which has been specially compiled, shows some of the trends in production, trade and consumption which has taken place with respect to the consumer and allied chemicals for selected years since 1929.

Production and Consumption of Consumer and Allied Chemical Products—Canada

(thousands of dollars)

	1929	1935	1940	1945	1950	1953
Production from chemicals and allied products industry	84,353	73,195	105,106	203,542	336,673	419,470
Production outside the industry	—	—	—	—	—	3,702
Total production	84,353	73,195	105,106	203,542	336,673	423,172
Imports (*Trade of Canada* chemicals and allied products series)	9,737	5,692	7,992	15,944	26,894	33,307
Other imports	12,204	11,369	10,050	11,480	34,248	26,064
Total imports	21,941	17,061	18,042	27,424	61,142	59,371
Supply	106,293	90,256	123,148	230,966	397,815	482,543
Exports (*Trade of Canada* chemicals and allied products series)	2,042	2,950	2,896	12,232	4,875	6,385
Other exports	119	203	579	4,355	3,802	4,715
Re-exports	n.a.	n.a.	8	4	23	21
Total exports	2,161	3,153	3,483	16,591	8,700	11,121
Apparent consumption	104,132	87,103	119,665	214,375	389,115	471,422
Total production as a percentage of apparent consumption	81.0	84.0	87.8	94.9	86.5	89.8
Total imports as a percentage of apparent consumption	21.1	19.6	15.1	12.8	15.7	12.6

[11]This should be contrasted with industrial chemicals, for which the relevant figure is in the order of 30%.

Although production appears to have been increasing at a rapid rate throughout the whole period, the performance of this sector of the chemical industry does not equal that of the industrial chemicals sector. In 1929 and 1935 production of consumer chemicals was the greater of the two. However, since 1940, the industrial chemicals have been growing at a faster rate. Imports of consumer chemicals meanwhile have lagged behind. Accounting for over 20% of total Canadian requirements in 1929, they have since fallen to 10% to 15%. Exports, on the other hand, have never been great. At present they constitute less than 2% or 3% of Canadian consumer and allied chemical production.

Various reasons can be given in explanation. One is that the optimum size of plant is better suited to Canadian conditions. Being smaller, they can be scattered across the country in close proximity to the principal markets for each product. Another is corporate structure. The great majority of firms are subsidiaries of parent companies whose headquarters are in the United States. Having been allocated the Canadian market they need not fear competition from similar goods produced across the line. In numerous instances, import duties are higher than those which apply in respect to industrial chemicals. Duty drawbacks are a rare occurrence since these products are rarely purchased by industry as "raw" materials.

The consumer and allied chemical products group of firms, consequently enjoys a measure of protection, and exhibits many of the characteristics common to secondary manufacturing in this country. It differs from the majority of firms producing industrial chemicals in that the latter, like many of Canada's other resource processing or export-oriented industries, are more exposed to competition on a global scale. Finally, the effects of advertising on the market for consumer products should be mentioned. North American in character, it tends by influencing consumer decisions to minimize the competition from overseas sources. Thus the consumer type chemical product, manufactured in Canada by a subsidiary of a United States firm, receives the benefit of continental advertising.

It is interesting to see where all this production goes. Over half is sold through wholesale and retail outlets directly for consumer use. Industry buys the remainder. It is rarely industry in the manufacturing sense. Paints are used in construction; also for maintenance purposes. Vegetable oils are incorporated in other foods. Adhesives are used largely in the manufacture of plywood and composite boards. Purchases by the consumer of durable and other steel products industries consist largely of paints and enamels. Hence, that part of the industry's output which goes to segments of the economy other than direct consumption is still devoted, in the main, to the production of consumer and other end goods.

The following detailed analysis of consumption includes consumer and allied chemicals from all sources, including industries whose principal activity is other than the manufacture of chemicals.

Consumption of Consumer and Allied Chemical Products in Canada: 1953

Consumption categories:	$000	% of total
Industrial chemicals	3,170	0.7
Consumer and allied products	18,791	3.9
Direct consumer use	263,208	55.2
Industrial uses:		
Agriculture	—	—
Plastics fabrication	—	—
Mining, smelting and refining	—	—
Construction and maintenance	82,201	17.3
Foods, packaging	55,944	11.7
Pulp and paper	—	—
Rubber and leather products	413	0.1
Steel products	22,142	4.6
Petroleum products	—	—
Electrical products	5,529	1.2
Textile products	487	0.1
Wood products	5,130	1.1
Miscellaneous	19,467	4.1
Total apparent consumption	476,482[a]	100.0

[a]This figure differs from that given in the previous table by $5,060 which is the value of allied products made in the industrial chemicals group.

Various reasons were given for the particular character of this important half sector of the Canadian chemical industry. An additional one, and one which would help to explain the relative insignificance of exports, is the United States tariff. Graduated steeply and placing prohibitive penalties on these near-to-finished products, it has effectively shut out all but a modicum of Canadian production from what otherwise could be an appreciable export market on this continent.

Paints, Varnishes, and Lacquers

Tradition is one reason for including the paints, varnishes, and lacquers along with the other chemical industries. Statistically, they have always been treated that way. Yet there are other reasons. One is that some of the materials which this industry uses are produced by firms using chemical processes normally classified as being in the chemical industry. Another is its close alliance through chemical research with the much larger industry

of which it nominally forms a part. By providing a market for a sizable number of industrial chemicals, it is, if not an integral part of the chemical industry, one of its closest allies on the demand side.

Nor can it be ignored on grounds of size. Its total value of sales puts it at the top of the allied chemicals group. In this respect, it is exceeded only by acids, alkalies and salts in the chemical industry as a whole. Consisting of some 123 plants, many of which are medium to small in size, it has ramifications right across the country. No Canadian province, except Prince Edward Island and Saskatchewan, is without at least one plant. Those in the more highly populated areas, however, tend to be larger and certainly more numerous. Southern Quebec and Ontario boast nearly 100 of them and turn out between 85% and 90% of the total value of output of the industry.

The five major firms in the industry[12] each operates several plants at different locations. All five are controlled outside Canada. The numerous smaller companies fall into one of two categories: they either produce a line of specialized products, such as metallic paints, anti-corrosion paints or cement paints; or they produce a relatively complete line of paints for distribution over a relatively small geographic area.

Paint-making is today a mixture of tradition and the application of the newest chemical materials and methods. Until the end of World War I, the types of paint available were very restricted. For indoor or outdoor use, for painting homes or for industrial use, there was one main kind of paint mineral pigment ground in an oil such as linseed oil. One could of course use whitewash (lime dissolved in water), and varnishes, shellacs and lacquers were made with natural gums and resins.

In the 1920's, chemical research produced the nitrocellulose lacquers for use as automobile and industrial finishes and as high-gloss paints for woodwork and furniture. Nitrocellulose, which had been produced during the war in huge quantities for use in smokeless propellant powder, was modified and dissolved in organic solvents, with pigment added. The surface coating produced by the application of these lacquers was tough and resistant, but most important, it was quick-drying. Use of the lacquers was no small factor in permitting low-cost mass production of such goods as automobiles.

The traditional pigments have been much affected by chemistry. Chemically-produced titanium dioxide, a superior product, has more and more displaced the older white pigments such as lithopone, blanc fixe and white lead. Driers—chemicals added in small quantity to hasten the drying of

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[12]The three largest are: Sherwin Williams Co. of Canada Ltd., Canadian Industries Limited, and Canadian Pittsburgh Industries Ltd.

oil-base paints—have become more varied in type and more satisfactory in performance, and new solvents produced by petroleum refiners have proved to be superior as thinners. Water-based paints were introduced for tinting interior walls.

The most important developments in interior paints, though having their origins in the 1930's, have assumed major proportions since the end of World War II. The earlier easy-to-use water based paints were given their film-forming properties by casein (derived from milk) or glues. To supplement them came the resin paints. These form an excellent surface film, resistant to cracking and shrinking, hard, durable, washable, and quick-drying. The latest development has produced interior paints having these qualities in even more marked degree. These are the "rubber-based" or latex emulsion paints in which a type of rubber latex, usually high styrene butadiene type, is emulsified, together with pigment, in water. Still more recent is the development of vinyl and acrylic resin emulsion paints which are being used for exterior as well as interior coatings.

The advantages of the rubber-based vinyl and acrylic paints have revolutionized the home-decorating business and have probably more than anything else accelerated the "do-it-yourself" trend in home maintenance. Because of their ease of application, by brush or roller, they can be applied by anyone with excellent results. Because they are extremely quick-drying and almost odourless, rooms painted with them can be occupied again the same day.

The trend away from natural products and toward synthetics, manifest in so many industries, appears to be occurring in respect to lacquers and paints. In varnishes too, synthetic resins have replaced a part of the natural resins traditionally used. There are varnishes today based on synthetics which form films of a toughness previously unknown, making furniture or floors impervious even to hammer blows.

With these developments widening the application and acceptability of paint products, and with buoyant national income and increasing personal income in Canada, this industry has grown rapidly. As the following table shows, it supplies by far the greater part of the domestic market for these materials.

The very small imports of paint and related products are notable. Since the major part of the Canadian industry is foreign-controlled, relatively little research in these products is done in Canada and most new developments are "imported" after they have been introduced in other countries. The small volume of commodity imports in this field indicates that the imports of technology are made rapidly, that new products are made available quickly from Canadian sources to meet Canadian demand and that

Production and Consumption of Paints, Varnishes and Lacquers in Canada

(average annual value in millions of constant [1950] dollars)

Period	Domestic production	Imports	Exports	Domestic supply
1926-30	22.9[a]	1.1	0.5	23.5
1931-35	21.8[a]	0.7	0.6	21.9
1936-40	35.4[a]	1.1	1.5	35.0
1941-45	55.7	1.6	1.5	55.8
1946-50	77.9	2.1	1.7	78.3
1951	84.9	2.3	0.9	86.4
1952	83.4	2.2	0.6	85.0
1953	88.5	2.9	0.5	90.9
1954	84.3	3.1	0.5	87.0
1955	94.3	3.7	0.7	97.3

[a]Includes some pigments.

domestic producers are alive to the need for keeping up with the rest of the world in paints and varnishes.

The figures above, however, do not indicate the extent to which the industry's raw materials have been supplied from outside sources. Although Canada produces some of her own requirements of pigments, imports of these amounted to $19 million in 1955. Two of the pigments imported in largest quantity were titanium dioxide and carbon black. Since 1952, a plant to supply the Canadian carbon black market has been brought into operation, and a plant to make titanium dioxide pigments in Canada is now under construction.

These developments are illustrative of a tendency which is marked in respect to most of the raw materials consumed by the paint products group. Turpentine; the principal thinner for paints until recent years, was largely imported into Canada; its place is now being taken by petroleum distillates coming from Canadian refineries. Linseed and soya oil, and the different naphtas for paint and lacquer solvents have for many years been produced in Canada. Other materials which have recently become available in quantities sufficient to meet all domestic needs include: phenol, phthalic anhydride, formaldehyde, pentaerythritol and isopropyl alcohol. A marked tendency toward self-sufficiency in paint raw materials is also to be noted in the replacement of such natural products as resins, formerly imported from all over the world, by the synthetic resins like alkyds, urea formaldehyde and others, which are produced in Canada.

The Canadian paint industry bears almost the same size relationship to the United States industry as applies to the populations of the two countries. Thus production per capita is about equal in the two countries.

In fact, over 95% of the Canadian market is supplied by plants in this country. It is generally true that most other industrialized nations meet the bulk of their own finished paint requirements.

The market for paint is determined partly by the level of new construction and partly by the activity of many industries which use paint products to finish their own products. These demands in Canada have been growing at an average rate of about 5% per year over the past quarter century.

Medicinals and Pharmaceuticals

The second largest, and one of the most rapidly growing sub-industries in the consumer and allied chemical products group is comprised of plants manufacturing and otherwise processing medicinals and pharmaceuticals. In 1955, its total value of sales was in the order of $100 million.

Some idea of the relative rate of growth both of Canadian production and the Canadian market can be obtained from the following table:

Medicinal and Pharmaceutical Preparations
Canadian Production and Consumption[a]
(in millions of current dollars)

Year	Domestic production	Imports[b]	Exports	Apparent consumption
1920	11.7	2.1	1.0	12.8
1930	13.9	3.6	0.6	16.9
1940	21.1	4.3	1.3	24.1
1950	69.3	18.6	4.3	83.6
1951	82.1	22.4	6.0	98.5
1952	81.4	21.8	5.1	98.1
1953	87.1	22.4	5.7	103.8
1954	90.8	25.0	5.5	110.3
1955	96.2	24.6	4.2	116.6

[a] Medicinal and Pharmaceutical Preparations, Annual, D.B.S. and Trade of Canada. Production is exclusive of non-medicinal products and is a tabulation from all industries.

[b] Excludes certain items for which trade statistics are not published due to the fact that only one or two companies are engaged in the trade of such products.

It is commonly said that half or more of today's drug sales are products not yet ten years old, and that 15 years ago over 80% of the prescriptions which doctors now write could not have been filled. While this may be something of an exaggeration, it does serve to underline the growing importance of the numerous vitamins, sulpha drugs, antibiotics and hormones, which have been discovered and developed since the early 1930's.

It was only in 1936 that the first sulpha drugs reached North America, and it was only in 1941 that penicillin was first used in England. World

War II stimulated both research and trade in pharmaceutical and medicinal chemicals, and activity in this field of production has been mounting ever since. Witness the fact that streptomycin, cortisone and aureomycin, have all been successfully introduced over the past few years. Promising as they do to overcome such diseases as tubercular meningitis, typhoid fever and pneumonia, the demand for them would appear to be insatiable, providing the incentive to continue research along similarly promising lines.

In dollar terms nearly three-quarters of the industry's sales goes to makers of "ethical"—that is to say, drugs advertised only to the medical profession and intended for sale only on prescription. The other quarter goes to firms manufacturing "proprietary" medicines—the name for that great range of headache pills, cough medicines and other nostrums sold by direct appeal to the sufferers themselves.

Production of Medicinals and Pharmaceuticals in Canada
(thousands of dollars)

	1920	1941	1945	1953	1954
Total production, medicinal and pharmaceutical group	15,728	35,472	60,331	93,557	97,396
Production of ethical pharmaceuticals (estimated)[a]	6,539	20,833	34,434	66,305	70,247
Pharmaceuticals as a percentage of total production by the group	41.6	56.5	57.1	70.9	72.1

[a]This estimate formed part of a submisison to the commission by Mr. Eliot S. Frosst, President, Charles E. Frosst & Co. At other points in the following text this section of the report has drawn on data presented by Mr. Frosst.

The first division is the more notable, in that there are still only a relatively few manufacturers of ethicals. This is because most of these chemicals are relatively new, and must be made on a scale which requires considerable capital and frequently necessitates a great deal of continuing research. The list of "ethical" houses is headed by a handful of well-known firms, all of which operate extensive laboratories in the United States and elsewhere.

As a result of these trends the position of retail stores is changing. Few druggists now do much compounding themselves. In the main, they have become salesmen of goods manufactured, prepared and packaged in large factories under conditions of sterility which the corner drug store could never hope to attain.

These requirements together with the economies of large-scale production are tending to centralize the manufacture of pharmaceutical and medicinal chemicals in the hands of a relatively few firms. Most Canadian plants,

while they make certain drugs themselves, import many others in bulk, applying their specialized knowledge to compounding and packaging them.

Canadian drug firms now number 216. Of these, 26—the majority of them controlled outside Canda—accounted for some two-thirds of all Canadian drug sales in 1955.[13] Most of the larger U.S. and certain of the better known British pharmaceutical firms have subsidiaries in Canada, some operating manufacturing facilities and others only warehouses and packaging plants.

The volume of imports tends to be understated by available statistics, expressed in value terms. The latter are exclusive of the considerable "value added" involved in the payment of duties and subsequent processing and packaging costs incurred in this country after importation. Hence, it follows that a considerably higher proportion than 20% of Canadian consumption is actually purchased outside the country.

The reasons for this are not hard to find. The Canadian market is not always large enough to support plants of economic size. This is reflected in the statistics of the U.S. and Canadian pharmaceutical industries as a whole. The average Canadian factory is appreciably smaller than its American counterpart. It produces about two-fifths of the value of output, and about two-thirds the output per man-year achieved in the United States.

Comparatively little research and development is carried on here. There are important exceptions, such as the development of insulin by the Canadians Banting and Best for diabetes control. Generally speaking, however, most products are discovered, tested and initially produced elsewhere. Then, capitalizing on the continent-wide advertising which accompanies the introduction of these new substances, production may, somewhat belatedly, get under way in Canada.

For the non-integrated Canadian firm, willing to take some initiative in these matters, the pharmaceutical business can be risky. There is the danger of producing products which meet all the laboratory tests and yet may be unsatisfactory or even dangerous in general use. Certainly, this has happened elsewhere with respect to chemical agents, antibiotics and vaccines, and resulted in a serious loss to producers. The possibility of substitution must also be taken into account. Rapid obsolescence of products, as a result of research in laboratories in widely separated parts of the world, makes flexible operations an essential element of survival.

This is the present situation; but what of the future? Experiments are now in progress which promise to bring about a number of changes in

[13]The larger producing firms include: Ayerst, McKenna & Harrison, Ltd., Charles E. Frosst & Co., Merck & Co. Ltd., Parke, Davis & Co. Ltd., E. R. Squib & Sons of Canada Ltd., Abbott Laboratories Limited, Ciba Co. Ltd., Sharpe & Dohme (Canada) Ltd., and John Wyeth & Bros. (Canada) Ltd.

pharmaceutical practice, each as dramatic as that caused by the sulphonamides before the war. It started with the isolation of the antibiotics. The remarkable thing about penicillin, for instance, is the range of disease organisms which it can destroy. It is possible that antibiotics and related substances may be found which will destroy or control any kind of disease organism and of such variety to offset any resistance which develops. Also, while the antibiotics appear to overlap in certain instances, they are freqently found to be complementary in their effectiveness against disease.

A growing range of vitamins has been in production for many years, but for a long time they were used only to compensate for deficiencies in natural sources of supply. It now looks as if their use can be extended to those diseases which are accentuated by diet deficiencies. However, the line of development is not as clear as in the case of antibiotics, for although it is known that the human body requires certain chemicals, it is still by no means certain how it uses them.

Hormones offer analogous possibilities. Some of them can already be produced synthetically. Others are still obtained from natural sources. However, since natural supplies are frequently too limited to meet the growing demand for hormones, strenuous attempts are being made to produce these drugs by synthesis, or to find chemical alternatives for them.

Production methods and new products are developed to take the place of older ones. There is some risk of excess capacity in the industry. Canadian, British and American firms have, since World War II, been able to overcome this by exporting much of their production, particulary to areas where productive capacity had either been destroyed or which were deprived of their customary supplies. Recently, however, there is evidence that price cutting has been necessary to retain some of these markets. Furthermore, when firms in other countries such as Germany are back in full production further adjustments may have to be made.

Soaps and other Surface Active Agents

Soap, largely a home-made article until late in the 19th century, was by 1900 being manufactured in numerous small factories scattered across the country. Since then, this industry's operations have become concentrated in the hands of a relatively few major producers; companies which first rose to prominence in the United States or the United Kingdom and which now dominate the Canadian market as well.[14]

As in the case of many other products, synthetic detergents[15] have really

[14]Lever Brothers, Proctor and Gamble, and Colgate-Palmolive account for most of Canadian production.

[15]The synthetic detergents are part of a general class of compounds called "surface active agents", sometimes abbreviated to "surfactants" by the chemists, which are not only used as cleaners but also as anti-wetting agents, as emulsifiers and in a dozen other ways to make solutions behave.

been known for many years. As early as 1916, German dye manufacturers adopted them in an effort to reduce the deteriorating effects which soaps were having on textile dyes. Their experiments began to attract attention on this side of the Atlantic in the early 1930's, but it was not until after World War II that commercial production really got under way. Industrial uses and the prospect of large household sales caused new manufacturing capacity to be set up first in the United States and, in 1947, on a relatively large scale in Canada. Since then, Canadian production has gone up sixfold, over-all sales by about the same amount.

Future increases in the use of synthetic detergents are not likely to be as precipitous as they have been in the recent past. Finding particular appeal in hard water areas, where the natural soaps produce a lime scum and are less efficient, they have already taken over nearly 60% of the total soap market in North America. Widely accepted in the home[16], they have also been adopted in industry, where the older type soaps were handicapped largely by their chemical properties. The fact that the synthetic detergents are more stable in price and can be tailor made to suit a variety of applications is also in their favor, another reason why it is assumed that within a relatively short time synthetics will claim up to 75% of the total soap market here.

The table below indicates the production progress which these newer soaps have already made in this country, and something of their impact on the older "natural" product.

Canadian Production and Consumption of Soaps and Synthetic Detergents

(millions of pounds)

Year	Production		Imports		Exports	Domestic supply	
	Soaps	Synthetics	Soaps	Synthetics	Soaps	Soaps	Synthetics
1946	232	3	6	(2)	20	218	3
1947	224	22	17	(2)	12	229	22
1948	240	35	9	16	3	246	51
1949	215	37	5	24	2	218	61
1950	232	52	6	19	0.2	238	71
1951	197	70	5	13	0.2	202	83
1952	196	87	5	11	0.3	201	98
1953	182	115	6	7	0.2	188	122
1954	165	122	6	8	0.2	171	130
1955	150	136	8	12	0.2	158	148

[16]In the United States, it is presently estimated that about 75% of all soap sold for household use is of "synthetic" variety.

Such developments in the soap industry have not been without attendant raw material repercussions. They have helped, on the one hand, to ease the pressure on the world's supply of fats. At the same time they have tended to limit North American output of glycerine, the major by-product of natural soap production and an essential raw material in such industrial applications as the manufacture of explosives.

The growth of the synthetic detergents, meanwhile, has exceeded the demand for certain petrochemicals. Petroleum derivatives in the form of alkylates have been rapidly taking the places of natural fats and oils used in soap, thus resulting in an increased demand for such "builders"[17] as sodium tripoly-phosphate. New capacity for making these chemicals has been rapidly built up, however, and shortages which were characteristic of this industry a few years ago are now largely a thing of the past.

Canada, although largely dependent on the United States for the petroleum-based alkylates, has become self-sufficient in respect to the phosphates and other non-active ingredients. The present capacity to manufacture these substances is already more than double what it was five years ago, and further construction is under way.[18]

If American experience can be taken as any guide, there is still a good deal of room for expansion in this country. In order for synthetics to meet, say, three-quarters of Canada's domestic soap requirements, output will have to expand by nearly 50%. As the market grows, certain of the alkylates are bound to be produced here. Plans for one group (the alkyl-aryl compounds) which is still imported, have already been announced.[19] Then, again, per capita usage in Canada is much lower than in the United States, a fact which can be largely explained by the proportionately heavier demands stemming from secondary manufacturing south of the border. So, with these various influences at work, both change and expansion are likely to be characteristic of this sizable sector of Canada's chemical industry.

A word remains to be said about the industry's structure. The gross value of production of firms principally engaged in the manufacture of soaps, washing compounds and cleaning preparations was in the order of $100 million in 1955. They were located primarily in Southern Ontario and Quebec. Though this industry appears to be market-oriented, its location in future will be influenced more by the availablity of petrochemical raw materials than by the existence nearby of meat-packing and other food

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[17]"Builders", which perform such functions as holding dirt in suspension after the detergent has removed it from the material being washed, include various sodium phosphates and sodium carboxymethyl-cellulose. Most of these compounds, as is the case with the majority of additives used, are available from domestic sources.

[18]The Electric Reduction Company of Canada Ltd., is the producer in Canada.

[19]Imperial Oil Ltd., will produce dodecyl benzene in Canada in 1957 at Sarnia.

processing industries which are searching for markets for their seasonally surplus by-product fats and oils.

Other Consumer Chemicals

Toilet preparations

This industry, which produces a wide range of such products as lotions, cosmetic creams, hair tonics, shampoos, face powders and perfumes, is largely oriented to the domestic market. Imports are small; exports negligible. In the main, the industry consists of firms whose operations reflect the methods of production and advertising initiated by their parents in the United States. Certain of the basic materials are made in this country. However, a goodly proportion is also imported for mixing, packaging and distribution to consumers in Canada.

The following statistics, while they relate only to finished products, indicate that this minor segment of the chemical industry is currently growing at a rate somewhat in excess of personal income:

(millions of current dollars)

Year	Domestic production	Imports	Exports	Available supply	Personal disposable income
1950	29.1	0.4	0.1	29.4	13,414
1951	30.9	0.6	0.1	31.4	15,693
1952	37.3	0.9	0.1	38.1	17,214
1953	39.5	1.4	0.1	40.8	18,132
1954	41.1	1.6	0.1	42.6	18,222
1955	44.7	1.5	0.1	46.1	19,683

Polishes and dressings

This industry, like many others in this miscellaneous group, is concerned more with compounding than with chemical processing as such. Of the approximately $20 million worth of products which it manufactured in 1955, well over half was floor wax. This material and other polishes were made from a variety of imported natural products, paraffin and such materials as ethyl alcohol and sodium carbonate, the latter two coming from Canadian sources.

Both imports and exports are comparatively small. The majority of producers are located in Quebec and Ontario, many of them being subsidiaries of United States concerns.

Inks

This industry is chiefly concerned with the production of printing ink. Some $12 million worth was produced in 1955. Imports and exports of the

finished product continue to be insignificant though several ink manufacturers in this country make up their own colour lakes from imported materials.

Adhesives

Some $11 million worth of chemical products are currently being made each year by firms in this industry. Synthetic products—especially resin glues—are on the increase. Currently they are challenging the old-time bone and hide glues in many of the latter's applications. Other significant products are liquid vegetable glues made principally from flour and starch. The 29-odd plants currently operating in this industry are located principally in the central provinces. Among the chemical materials which they purchase in bulk are phenol, various synthetic resins and urea.

The main outlet for adhesives is in the plywood industry. The largest plants are therefore located in British Columbia, Alberta, Ontario and Quebec.

Vegetable oils

The vegetable oil processing industry, like paints and varnishes, can hardly be said to be a chemical industry. Yet statistically it is so classified for two reasons: because the techniques it uses are similar to those employed in chemical processing and because its products are frequently sold in competition with those of a synthetic nature. Its operations and marketing problems are in other words, similar to those encountered by industries which are more distinctly chemical in character.[20]

Currently its annual value of production is in the vicinity of $50 million. The majority of its output is sold principally to meat packing and other food processing concerns, and to firms making paints, soaps and like chemical end-products.

The business of this industry is to extract oils from vegetable materials—linseed oil from flax seed, soya oil from soya beans, and so on. Oilcake, a major by-product, is sold widely for animal feeds.

There are few signs to date that either the structure, raw materials intake or process technology of this industry will be radically altered by developments elsewhere on the chemical front. Only in one instance—that of a drop in the demand for vegetable oils required in the manufacture of soap—can market forces originating in the chemical area be assumed to affect the reasonably steady level of output which has been maintained since 1950.

Since that year, production by the vegetable oils industry has been in

[20]U.S. statistics are also organized in this manner.

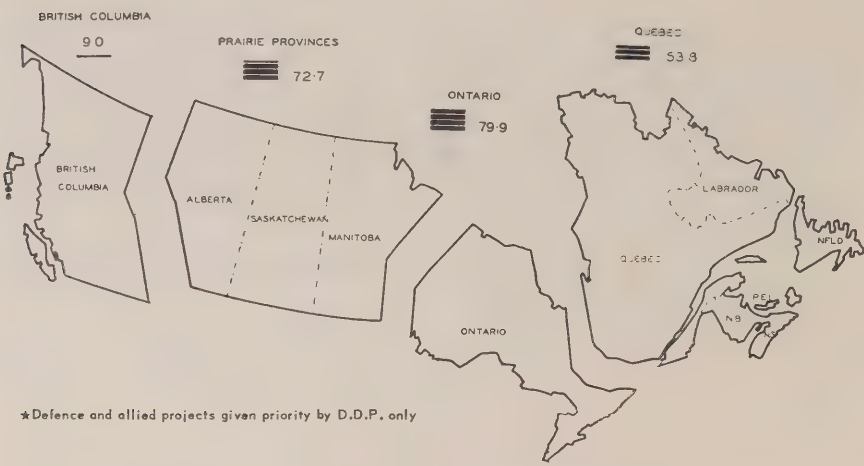
the neighbourhood of \$50 million annually. It should be noted however that about 40% of this production leaves the factory in the form of oilcake. The production of vegetable oils alone therefore is closer to \$30 million annually.

Domestic production is supplemented by an almost equivalent volume of imports. These consist of the near tropical oils such as cocoanut oil, palm oil and chinawood oil, as well as large importations of cottonseed oil, soya bean and peanut oils. Many of these are now processed in the United States for export to Canada and other countries whereas before World War II, Canadian imports of these oils came largely from processing plants in the United Kingdom.

Exports of linseed, flaxseed and other Canadian processed vegetable oils amount to about \$5 million annually.

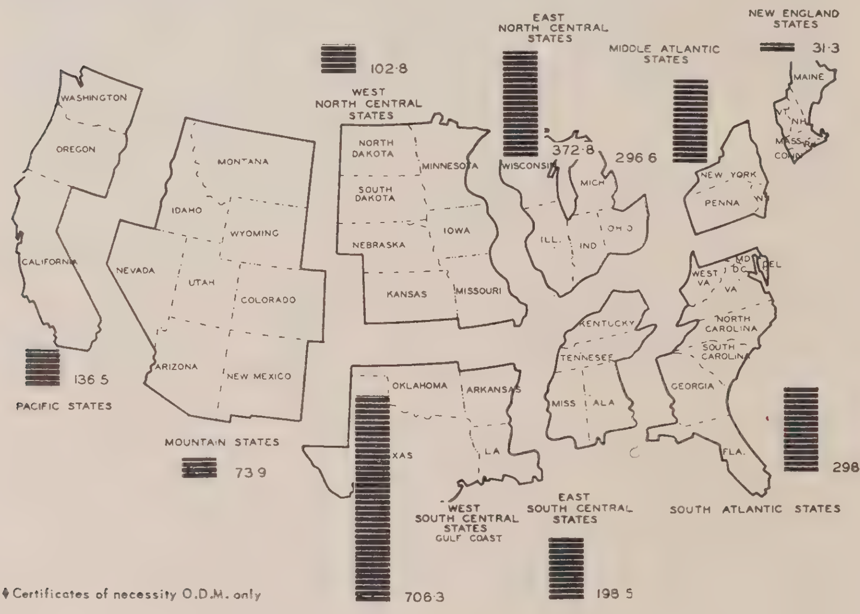
NORTH AMERICAN CHEMICAL PROJECTS

CANADA 1950 – 1955 ★
Investment in millions of dollars (Can.)



★Defence and allied projects given priority by D.D.P. only

UNITED STATES 1950 – 1955 ♦
Investment in millions of dollars (U.S.)



♦Certificates of necessity O.D.M. only

5

THE CURRENT EXPANSION PROGRAMME

SINCE the outbreak of war in Korea in 1950, capital expenditures in Canada's chemical industry have twice risen to record breaking levels. One expansionary wave was completed in 1953. That currently under way promises to involve even greater outlays and to stretch well into 1958. (For a chronological record and comparison of investment expenditures in Canada and the United States over the past decade see the accompanying charts: Expenditures for New Plants and Equipment, United States and Canada 1946-1956; and North American Chemical Projects, Canada and the United States 1950-1955.)

In the current expansion programme of the chemicals and allied products industry, one-half of the planned capital expenditures are on facilities for petrochemicals, both organic and inorganic. (See table entitled Capital Expenditures by Chemicals and Allied Products Industries Canada, 1946-1956.)

To grasp the significance of this, it may be noted that in the period 1947-54 one-half of the 8% annual expansion in output of the acids, alkalies and salts industry was in petrochemicals (excluding fertilizers, plastics, rubber and elemental sulphur production). The balance of 4% was in line with the average annual rate of expansion of manufacturing generally. There is thus a reasonable basis for the statement that the growing layer of the heavy chemicals tree is petrochemicals production. They provide an alernative source to traditional raw materials for a wide variety of products such as detergents, fibres, solvents, plastics, synthetic rubber, etc., and currently account for 50% of the value of industrial chemicals produced in the United States and Canada, and 80% of the value of organic chemicals.

Investment

The accompanying table, which records capital expenditure in the chemical industry by major sector since 1945, indicates that whereas some falling off in investment has taken place in the heavy chemicals and primary

plastics categories, spending in most other categories is presently well above the peak levels previously achieved in 1952.

Capital Expenditures by Chemicals and Allied Products Industries[a] Canada

(In millions of current dollars)

(1946-56)

Product category[a]	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955[c]	1956[d]
Acids, alkalies and salts	2.5	5.8	10.9	6.6	5.5	11.5	82.4	78.8	8.6	19.7	43.1
Fertilizers	2.5	1.4	1.7	1.9	2.0	3.1	7.4	5.6	1.7	8.3	15.3
Medicinals and pharmaceuticals	4.5	4.1	2.4	2.0	1.4	2.8	2.3	2.3	4.8	6.2	6.0
Paints and varnishes	2.4	5.4	2.9	1.6	1.3	2.7	2.0	2.5	4.0	3.9	6.8
Soaps and cleaning compounds	b	b	4.9	7.6	4.5	3.4	3.3	2.7	1.7	1.6	2.9
Primary plastics	2.1	2.8	7.4	10.5	5.0	5.9	12.0	14.5	2.2	2.6	3.9
Compressed gases	b	b	0.8	1.0	1.8	1.8	1.9	2.8	2.8	2.9	3.0
All other	13.3	22.9	19.2	15.1	10.9	34.0	38.9	23.6	32.3	23.6	74.5
Total[e]	27.3	42.4	50.2	46.3	32.4	65.2	150.1	132.8	58.1	68.8	155.5

[a]Including synthetic fibres.
[b]Included in all other.
[c]Preliminary.
[d]Forecast.
[e]May not equal components due to rounding.

Return on Investment for Manufacturing and the Chemical Industry in Canada[a]

(net operating income as percentage return on average operating investment[b])

	Manufacturing industry	Chemical industry	
	Before taxes	Before taxes	After taxes
1948	11.8	12.5	
1949	10.3	10.3	
1950	12.3	13.5	8.1
1951	12.9	15.3	7.0
1952	10.3	11.9	5.8
1953	9.4	8.9	4.9
1954	7.0	7.3	3.9
1955	(8.0)	(8.0)	(4.5)

[a]Bracketed values are estimates, based on preliminary data. Chemical industry refers to companies engaged mainly in the manufacture of chemicals and allied products; the returns on investment include profits from their operations which are not of a chemical nature.

[b]Operating investment is the total undepreciated assets exclusive of goodwill, patents, and processes and investments in shares of subsidiary and other companies. The average is based on the investment at the beginning and end of each calendar year.

It should be remembered that the per capita usage of chemicals in Canada is still only about half that in the United States. With the increasing need to process resources for export, on the one hand, and the prospect of a greater measure of secondary manufacturing in this country, it can be seen that the expansionary forces behind Canada's chemical industry are far from being spent.

The calculated rate of return on investment before taxes shows it varying from a high of 15% to a low of 7% over the past half-dozen years. (See accompanying table entitled Return on Investment for Manufacturing and the Chemical Industry in Canada.) The yield after taxes, meanwhile, has fallen since 1950. From a high of approximately 8% five years ago it is now in the order of 4.5% In this respect it parallels the experience of most other types of manufacturing. However, for manufacturing as a whole, the corresponding drop has been from 13% to around 8% before taxes.

Financing

Usually, Canada's chemical firms have been financed in the initial stages by the direct transfer of funds from other countries, particularly the United States and the United Kingdom. Later, as these companies have expanded their operations, they have raised most of their capital from retained earnings. Control, in other words, has remained substantially in the hands of those who have initiated these developments. Their rate of growth, meanwhile, has been conditioned by the development of the Canadian economy generally.

Only limited appeals for funds have been made to the Canadian capital market in recent years. Dominion Tar and Chemical Company, DuPont of Canada, Canadian Industries Limited and Canadian Chemical Company Limited are the only major incorporated companies which have allowed public participation in their Canadian operations. While the public has also participated in the petrochemical subsidiary of British-American Oil and Shawinigan Chemicals through recent issues of convertible debentures and common stock of British-American itself, most other large chemical firms have found it unnecessary to appeal to the market. Instead, they have continued to raise their investment capital through earnings, the floating of bond issues and, occasionally, the sale of physical assets.

According to the latest statistics published by the D.B.S. (1953), the total investment in this country's chemical industry amounted to some \$572 million. Of this, Canadians owned 29% and controlled 28%; American interests owned 46% and controlled 54%; and other foreign corporations and individuals, many in the United Kingdom, owned 15% and controlled 18%. Since then, additional investments have been made and these ratios have changed. Canadian and American participation has declined slightly and that of other countries increased.

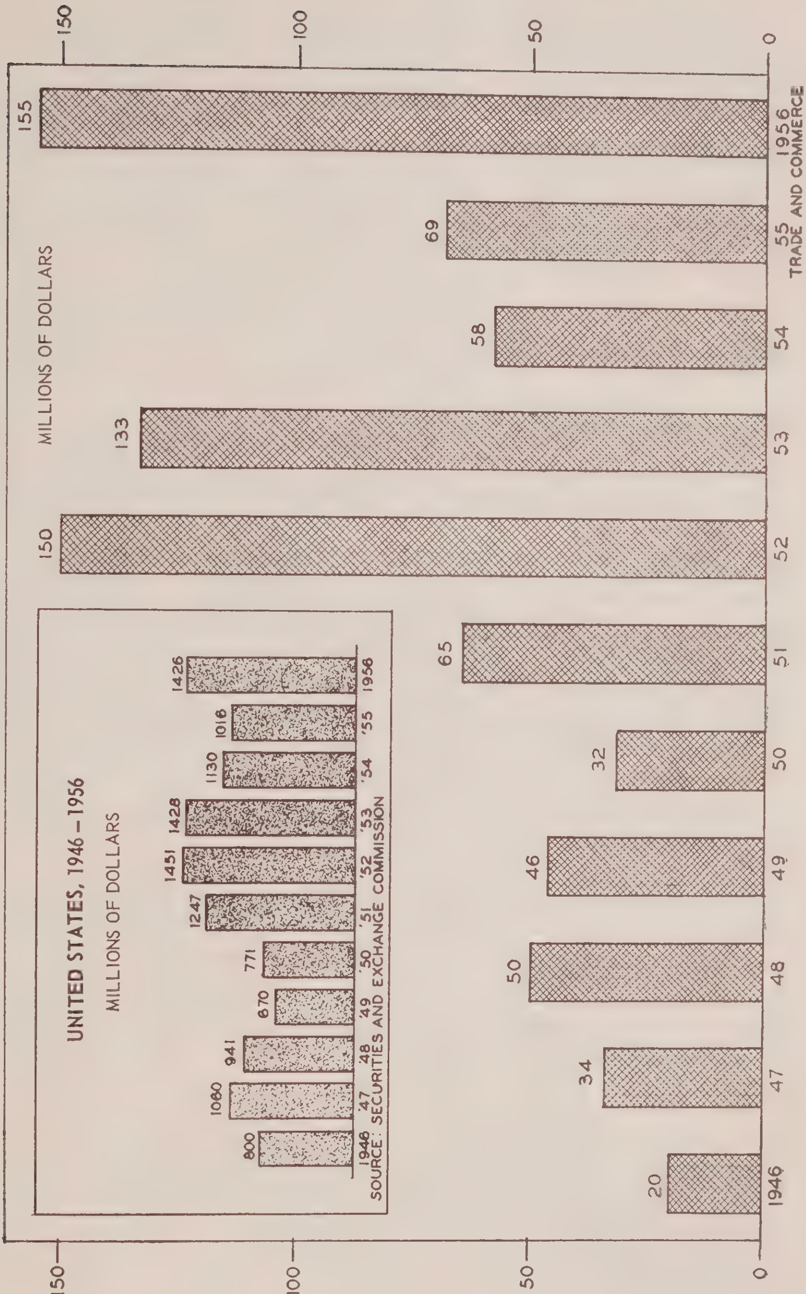
The following table gives a more detailed account of the extent of foreign and domestic control in the chemical industry.

Value of Output and Employment in Chemical Plants Controlled by Residents and Non-Residents, 1954

(as percentage of total)

	Net value of production		Employment	
	Industrial chemicals	Consumer chemicals	Industrial chemicals	Consumer chemicals
Controlled by residents	33	26	33	31
Controlled in United States	56	50	55	43
Controlled in United Kingdom	8	24	9	26
Controlled in other countries	3	—	3	—

EXPENDITURES FOR NEW PLANTS AND EQUIPMENT, CHEMICAL AND ALLIED PRODUCTS,
CANADA, 1946 – 1956



6

FUTURE GROWTH PROSPECTS

Introduction

Future trends in any industry are difficult enough to predict, but in chemicals one thing is certain; they will continue to move upward for many years to come. Trying to prophesy their order of magnitude of growth is a very different proposition, however. One must, at the outset, make some sweeping assumptions about future business conditions. This is because the demand for chemicals is already intimately associated with most phases of human activity. Then some stipulations must be made about changing commodity preferences and, finally, one must take a third and even bolder step in the realm of conjecture—that of prophesying future technological developments. Let us leave aside for the moment the limitations imposed by the size and character of the Canadian market, and consider what influence some of these other demand factors may have on the future growth of the chemical industry.

Looking back over the past 20 years, it appears that the chemical industry has been growing more rapidly than most of the other major industrial groups in North America. Since 1935, it has been expanding at an average rate of around 9% a year, *i.e.* doubling every eight years. This is all the more remarkable when it is remembered that the physical rate of growth of industry as a whole has been more of the order of 6%; that is, doubling every 12 years.

Of course, all segments of the chemical industry have not shared equally in this advance. Some have assumed much greater importance relative to others. But one thing has been true of all of them—they have continued to grow at rates at least as great, and frequently very much greater than most other segments of manufacturing which do not involve chemical change.

The following table gives some indication of the relative rates of growth of North American end-chemical production and rates of sales since the mid-1930's.

Estimated Growth Rates of 11 Major End-Chemical Groups

Actual 1935-50	Per cent per year	Predicted 1952-60	Per cent per year
Surface active agents	34	Plastics	14
Medicinal chemicals	19	Medicinals	12
Plastics	15	Anti-knock agents	9
Anti-knock agents	13	Fibres	9
Fibres	12	Surface active agents	8
Fertilizers	9	Synthetic insecticides	8
Synthetic insecticides	8	Solvents	7
Solvents	6	Synthetic rubber	7
Pigments	4	Dyes	6
Dyes	3	Fertilizers	5

SOURCE: *"Chemical and Engineering News"*, December 20, 1954, "Growth Trends in the Chemical Industry", by R. C. Miller and F. H. Good, Stanford Research Institute.

The industry's rise to prominence over the past half century has been due in large part to two quite different market phenomena, both of which will undoubtedly continue to play an important role in the future.

One consists of "replacement markets". Typical of these are synthetic fibres, plastics, synthetic rubber and such surface active agents as detergent soaps. These products are expanding at the expense of older commodities, usually natural in origin.

The other consists of "new markets", for example, medicinal chemicals, insecticides, new type fertilizers and the anti-knock agents used in gasoline. These products owe their popularity to the development and expansion of new outlets where their growth is rarely at the expense of other commodities.

Both categories of demand have been important in the growth of the chemical industry, but the replacement market has so far been the more important of the two. In the future it may be different. The "new market" category of chemical products may go on expanding indefinitely, but the "replacement market" category will eventually have to slow down as it reduces the sale of commodities which it is replacing.

For example, the synthetic chemicals used in fibre production will never exceed the ceiling imposed by the total demand for clothing, home furnishings, industrial fabrics and the like. Even if the present rate of growth of synthetics were to continue, they would fill the entire projected demand for fibres by about 1970. For obvious reasons they will hardly be that successful. This is one sector of the chemical industry whose rate of growth is bound to taper off during the next 10 to 20 years. The same reasoning applies to surface active agents, which are used in large measure as replace-

ments for the older soaps. Their sales have been expanding so rapidly that, if they were to continue, synthetic detergents would completely replace soap within ten years at the most. Here too it is obvious that the growth trend of this chemical group will be moderated in the not too distant future.

Synthetic rubber is making headway against rubber from natural sources. However, the principal gains here have been made in periods when overseas sources of the natural products have either been cut off or have been unable to expand rapidly in the face of mounting demands. Price stability has meanwhile become one of the chemical products' greatest sales features. While this may be a recurring phenomenon, only strategic considerations will entirely eliminate competition from plantations in the Far East.

Plastics are also largely replacement products. But they should really be considered as in a category by themselves. Tending as they do to replace such large volume items as steel, non-ferrous metals, glass, ceramics, leather and paper, there appears to be no forseeable ceiling to their consumption. Even wood appears to be losing out to them in some applications.

Neither do upper limits in the markets for medicinal chemicals, fertilizers or insecticides appear to be in the offing. Future sales of those products may be limited only by the rate of growth of the Canadian economy as a whole. A growing proportion of the national income will, in all probability, be diverted to such purchases.

In looking to the future one must also attempt some prophesies about new chemical products and entirely new markets. Some are already appearing on the horizon.

One consists of linking inorganics to organic compounds, a process by which the older branch of chemistry is being pulled into the immense stream of organic growth. The new hybrids are not likely to be as numerous as the organics themselves, but they have many possibilities. Among the oldest of these products are the chlorinated compounds, now used largely as solvents, refrigerants and degreasing agents. Among the newest and most promising are the organo-silicones or silicone plastics, which are finding application as heat resistant fluids, greases, resins and rubber-like materials. Then again there are the fluorocarbons, a notable new family being used as refrigerants, plastics of remarkable stability and synthetic lubricants. Each of these product families is still in the early, high-cost stage of development, but they promise to generate markets for themselves by making possible new inventions, some of which previously failed for lack of suitable materials.

Then there are many indications that numerous organic chemicals will evenually be made from coal by hydrogenation. One example of this has been the large-scale production in Europe of gasoline from coal by the Fischer-Tropsch process. This differs from coal tar chemistry in

that it sets out to build, either from the simplest molecules or from a whole new conformation of complex substances in coal, a wide and entirely new set of chemicals. It is being developed from both ends; by the oil companies, as an alternative source of gasoline, and by basic chemical manufacturers as a source of new materials for industry.

Another probability is the building of still more complex molecules in what might be termed "three dimensional polymerization". This means expanding out into the fields of protein chemistry and biochemistry, with the practical application of photosynthesis, perhaps the biggest event, just around the corner. Another growing province which promises to be of similar dimensions is enzyme chemistry, bringing in its wake a whole new range of natural catalysts. All this may apply a revolutionary force to food processing, as well as in the preparation of pharmaceutical and medicinal chemicals.

And, on the borderland, and still difficult to appraise, are likely developments in nuclear chemistry. Government and industry alike are doing considerable research in this direction, but it is still too early to expect tangible results beyond the use of radioactive isotopes as "tracers" and "measurers" in medical and industrial applications. But chemical science built up on a knowledge of the transformation of molecules, is bound to be affected by developments in atomic research. This is perhaps the most promising horizon of all.

Many processes in the organic chemical industry consist of moving the atoms or groups of atoms into different positions within molecules. The fast-moving atomic particles emitted by radioactive substances appear capable of effecting such rearrangements as effectively as the traditional tools of heat and pressure. What is not certain is whether they can do so more cheaply. In other words, if a great deal of radiation is needed to get results, and the value of the resultant chemical is low, such a process may not be commercially attractive.

The oil industry—always forward-looking in its research—is already interested. It is actively investigating the effects which radioactive source materials may have upon refinery operations and techniques. Other possibilities include the use of radiation in the polymerization of plastics. Were such techniques to be substituted for the standard high-pressure methods now in use, it could result in a substantial change in the size, shape and type of plant employed. A better product might also result. This is being proven in the case of polyethylene. Hence, an increased knowledge in the field of nuclear physics and nuclear engineering may lead to substantial changes both as to economies of scale and to competitive position, through improved quality of chemically-produced materials as opposed to those which occur naturally.

Forecasts of the Canadian Market

Various methods have been employed in an attempt to determine the size of the market for chemicals in Canada in 1980. The results, summarized in the following table, indicate that the domestic market may increase from approximately $1.25 billion in 1955 to between $5.5 billion and $6.5 billion 25 years hence. The various reasons for this prediction are given throughout the remainder of the chapter.

Summary of Forecasts of the Canadian Market for Chemicals in 1980

Method employed	Dollar value of market in 1980 ($ billions)	Ratio 1980 to 1955
(i) Straight line projection	5.0	4.0
(ii) Projection of past demand—G.N.P. relationship	6.2 to 8.1	5.0 to 6.5
(iii) Multiple correlation with G.N.P. and time	6.5	5.2
(iv) Correlation with population	4.5 to 5.3	3.6 to 4.3
(v) Analysis by principal end-use category	5.9	4.7
Range Ultimately Chosen as Most Probable	5.5 to 6.5	4.5 to 5.5

Straight Line Projection of Past Trends

When plotted, historical sales statistics, adjusted to constant dollars, follow a trend line such as is portrayed in the accompanying chart. (See chart entitled The Chemical Industry in Canada, 1926-1980.) They suggest a rate of growth approaching 6% compounded annually. This result is obtained using either of two time bases, *i.e.* by joining up the late 1930's and the postwar period, or basing the projection exclusively on apparent consumption data reported over the past decade.

Expressed in constant dollars, the forecast for 1980 would, using this method, appear to be in the order of $5 billion. Since Canadian chemical requirements in 1955 were in the order of $1,250 million, this points to a quadrupling in Canadian chemical usage over the next quarter century.

Projection of the Demand-GNP Relationship

It is possible, by projecting the past relationship between sales and GNP to allow for expected developments in other sectors of the Canadian economy. The result is a "theoretical" level of consumption which allows for a possible acceleration in economic development generally. It is an interesting

fact that the market for chemicals in Canada has risen steadily in relation to G.N.P. This changing relationship, together with the commission staff's expectation with regard to the latter, is therefore taken into account when using this approach. A note of caution is necessary, however. The resulting curve is parabolic in nature. By its nature, the results which it yields, therefore, appear to be on the high side. (See chart entitled Chemical Market in Canada, 1926-1980.)

Using this method and assuming a G.N.P. (1955 base) of $77 billion in 1980, chemical sales in that year might be expected to be in the order of $7 billion. The commission's high and low G.N.P. forecasts of $83 billion and $71 billion[1] yield annual sales estimates of $8 billion and $6 billion respectively 25 years from now. Here we have a range of possibilities which envisages Canadian consumption multiplying anywhere from five to between six and seven times over the next quarter century. Because these upper projections result in a ratio of chemical sales to G.N.P. (approaching 10%) which is inconsistent with the commission's other staff studies, a fivefold increase has been chosen to represent an upper limit as to future market possibilities in this country.

Multiple Correlation with G.N.P. and Time

It is possible, using the mathematical technique of multiple correlation to relate the chemical market in Canada, both to G.N.P. and to time. Demand, it appears, has been growing much more rapidly than G.N.P. (Canadian chemical consumption has risen from about 2.3% of G.N.P. in 1929 to around 5% in 1955). However, the rate at which it is gaining has tended to diminish with time. A statistical analysis which makes allowance for both variables can, however, be used to establish a "theoretical" level of consumption which, as far as the past 30 years are concerned, fits closely with actual experience. Using this method and again assuming a G.N.P. (1955 base) of $77 billion in 1980, chemical sales in that year are forecast as being in the order of $6.5 billion.[2]

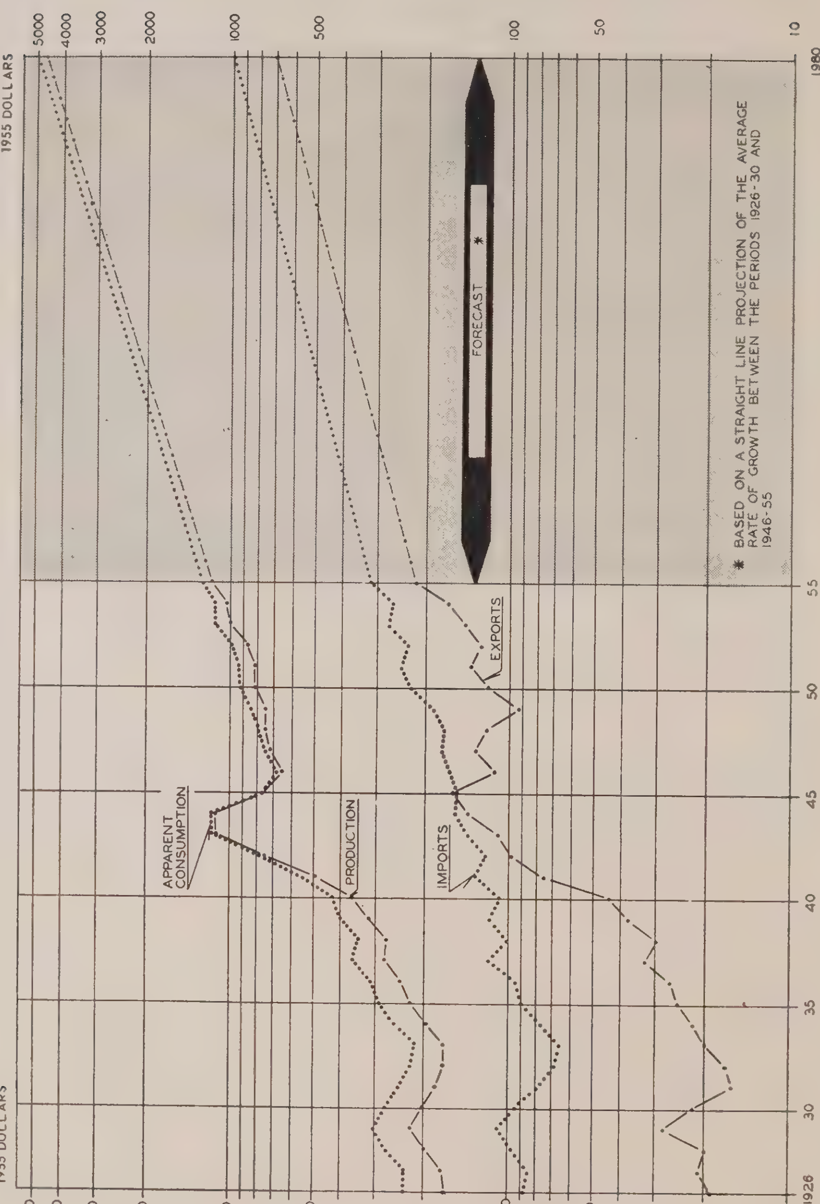
Correlation with Population

The correlation technique can also be employed to forecast the future relationship between population and chemical consumption in this country. Being a purely statistical approach, the results which it yields are necessarily dependent upon the span of past years which is used as a basis for such a projection. Data for the 30-year period, 1926-55, point to a lower level of sales than one based exclusively on the post-World War II period. Also, the forecast is automatically adjusted upward or downward depending

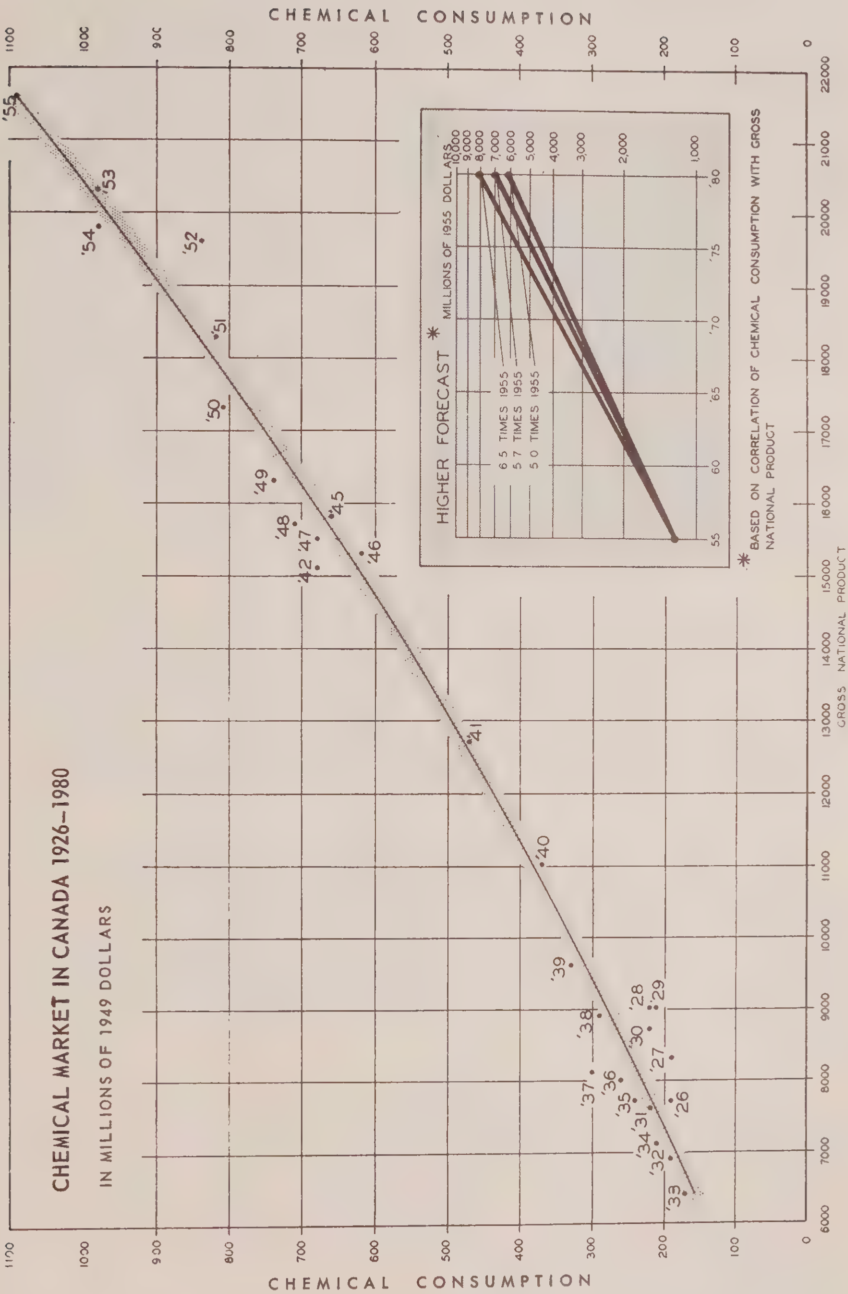
[1]These forecasts differ by about 1% from those given in the Commission's Preliminary Report, due to "rounding" of the 1949 dollars used in the calculations.
[2]The equation for the regression is as follows:

$$\text{Log Consumption} = 1.2133 + 1.2911 \text{ Log GNE} + .0025\ t$$

where GNE is in billion 1955 dollars and time is centred at January 1, 1940. For 1955 $t = 29$.



THE CHEMICAL INDUSTRY IN CANADA 1926–1980


CHEMICAL MARKET IN CANADA 1926–1980
IN MILLIONS OF 1949 DOLLARS
CHEMICAL CONSUMPTION
GROSS NATIONAL PRODUCT
HIGHER FORECAST *
MILLIONS OF 1955 DOLLARS
6.5 TIMES 1955
5.7 TIMES 1955
5.0 TIMES 1955
* BASED ON CORRELATION OF CHEMICAL CONSUMPTION WITH GROSS NATIONAL PRODUCT

on whether the projected figures for population in Canada in 1980 are on the optimistic or pessimistic side.

In this case, three population forecast figures were employed. They envisaged increases from 16 million to 25.8 million, 26.7 million, and 27.5 million a quarter of a century from now. The introduction of these into an equation derived from 1926-55 base period data yielded results which were subsequently rejected. Per capita consumption, it appears, grew at a lesser rate from 1926 to 1946 than it has done in the post-World War II period. Measured in percentage terms, its first 20-year growth rate was at the rate of only 3.5% compounded annually. It seems more realistic, therefore, to concentrate on experience over the past decade. The three above-mentioned population estimates, when used in an equation based on this more recent data, yielded growth ratios of 3.6, 3.9, and 4.3 times the 1955 market.

Striking a norm among these different results, we arrive at an estimate of chemical sales in Canada in the order of $5 billion in 1980. Like the straight line projection of past trends summarized previously, this points toward a quadrupling in Canadian chemical use over the next quarter century.

Analysis by Principal End-Use Category

Advantage can also be taken of the known quantitative relationships between chemical consumption and industrial output. Present day input-output relationships may, in other words, be projected into the future. In this way, different rates of growth, both among individual chemical-using industries and as between chemicals and other materials can be given in their appropriate weighting.

In each instance two variables are involved. One, the expected 25-year growth rate of the user industry or category, was obtained from other economic studies carried out by the commission's staff. The other, the changing intensity of use with time, was prepared in consultation with various experts in the chemical industry itself. The two, when multiplied together and applied to 1955 consumption statistics, resulted in an expected level of sales in 1980.

This method, which is essentially end-use analysis, must be treated with reserve. Although it may result in a reliable mid-term (up to five years) forecast, it often tends to be inherently conservative for the longer run. This downward bias results from its failure to take into account such developments as might result from the emergence of entirely new uses—requirements which are over and above those resulting from a further intensification of demand in existing uses.

 A further disadvantage is the problem of estimating future intensity ratios with any degree of accuracy. Not only are current statistics deficient

in this respect, but future possibilities are complicated by the multiplicity of fronts upon which chemical research and chemical sales can and indeed may, make sudden and unpredictable progress.

The result of multiplying present chemical consumption by both the industry growth and intensity of use ratios is detailed on the following page. The over-all conclusion is for a somewhat greater expansion in chemical consumption than has been indicated by two of the four aggregative methods outlined above.

A further word as to the greater and lesser influences for expansion may be useful. Half a dozen industries, because their volume of output is likely to outpace that of the rest of the economy, will exert a strong upward influence on chemical consumption. These include plastics fabrication, mineral processing, the manufacture of electrical apparatus and equipment, and expansion in the chemical industries themselves. Meanwhile, most (if not all) industries will use chemicals more intensively. This certainly applies to metal processing and fabrication, agriculture, and the manufacture of pulp by chemical means. Food processing, textiles, and the production of a wide range of other consumer end products are also expected to see more than a proportionate increase in chemical sales.

As a check on the foregoing end-use forecast, growth and intensity ratios for the chemical industry as a whole were worked out in the following way:

(a) The growth ratios for all chemical-using industries combined was taken as equivalent to the expected increase in G.N.P. between 1955 and 1980. Assuming a G.N.P. of $77 billion by 1980 (in constant 1955 dollars), a growth ratio of 2.9 is indicated. This is approximately equal to the weighted average obtained above;

(b) The value of chemicals consumed per unit of G.N.P. was calculated for past years and projected by various methods to 1980. The most probable increase in this proportion was found to be 55%; this implies an "intensity ratio" of 1.55 for industry as a whole; compared with the weighted average of 1.60 arrived at by a consideration of individual user industry behaviour;

(c) The product of the over-all growth and intensity ratios calculated under (a) and (b) indicates a growth in the total Canadian market of nearly 4.7.

Individual Commodity Group Projections

Available data on long-run North American consumption trends also provide certain leads. Commodity group projections, however, have little validity beyond a five- to ten-year period. Rising rapidly at first, consump-

Estimated Consumption of Chemicals in Canada

Principal use category	Column (1) Consumption, 1953 ($000)	Column (2) Industry growth ratio	Column (3) "Intensity" ratio	Column (4) Consumption, 1980 ($000)
Basic chemicals	98,239	6.0	1.0	589,000
Allied chemical products	73,721	4.0	1.3	383,000
Agriculture	75,320	1.9	4.0	572,000
Plastics fabrication	20,386	10.0	1.0	204,000
Mining, smelting and refining	32,608	3.5	2.5	285,000
Construction and maintenance	87,501	3.0	1.5	395,000
Foods, food packaging	102,507	2.6	1.7	453,000
Pulp and paper	47,215	2.2	1.8	187,000
Rubber and leather products	60,111	3.0	1.5	270,000
Steel products	33,207	3.5	1.5	174,000
Petroleum products	13,924	3.2	1.5	67,000
Electrical products	9,500	5.5	1.6	84,000
Textile products	93,126	2.0	2.5	466,000
Wood products	8,472	1.8	5.0	76,000
Miscellaneous industrial	58,258	3.5	1.5	306,000
Direct consumer use	290,694	2.9	1.6	1,349,000
Total	1,104,789	3.3	1.6	5,860,000

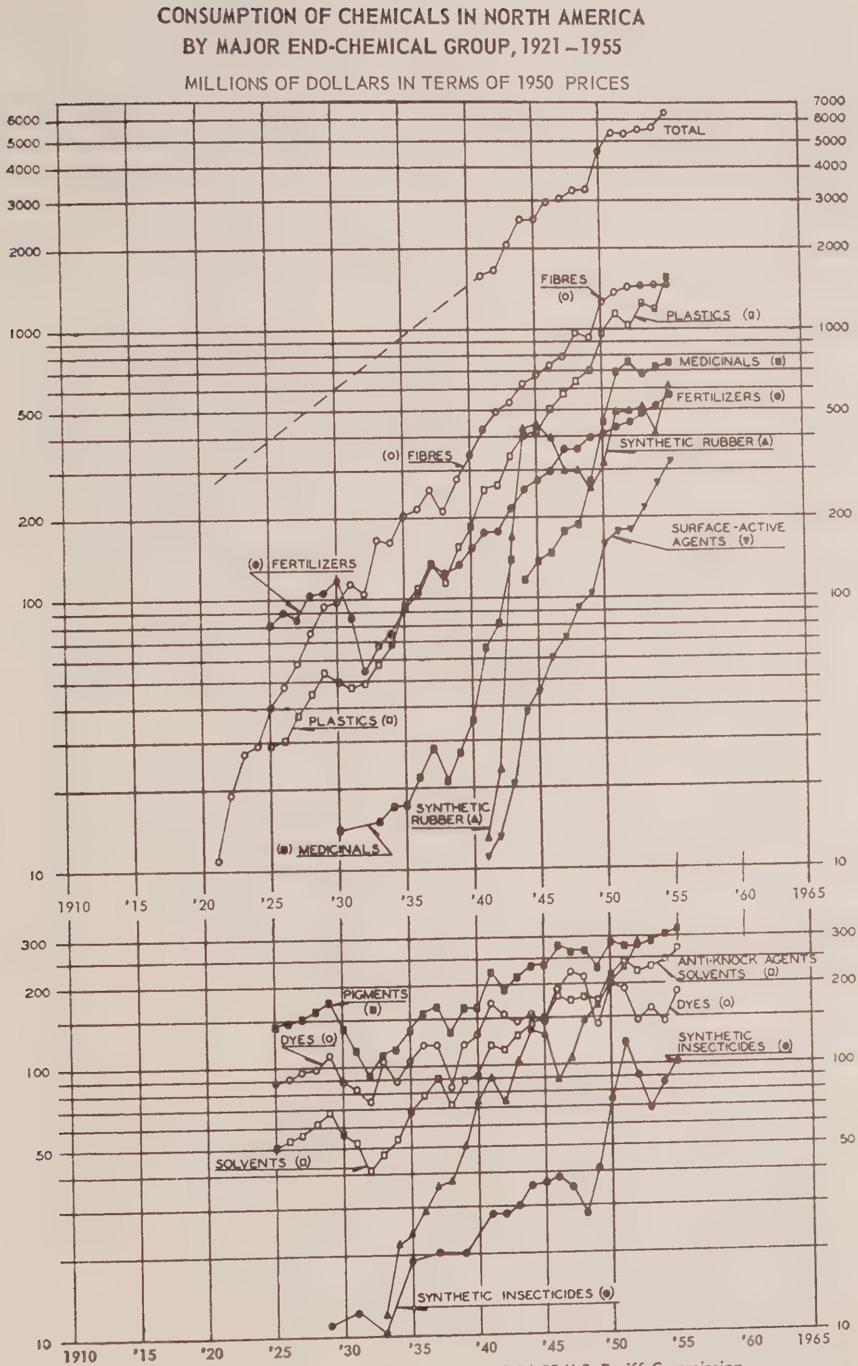
Average growth ratio: 1980 over 1955 = 2.9 (consumption in 1955 = $1,244 million)
Average intensity ratio: 1.6.

NOTE: Column (4) equals Column (1) × Column (2) × Column (3).

tion of each new synthetic material tends to moderate with time. Eventually, they parallel or even fall behind that of chemical consumption in general. Other and still newer families of compounds will, by then, be providing more of the dynamics of growth. These subsequent possibilities are often missed in any commodity by commodity forecast. Like the end-use method, it is therefore likely to understate the possibilities for the future. Its failure in this respect increases with time.

The accompanying chart (See Consumption of Chemicals in North America by Major End Chemical Group, 1921-1955), while indicative of total North American rather than Canadian consumption trends, illustrates the changing importance of the major end-chemical groups. Reasoning from this it would appear that, during the next decade, plastics may surpass synthetic fibres in value terms. Medicinals will probably extend their recent lead over synthetic rubber. The accompanying graphic material also suggests that there is still considerable room for expansion in respect to the newer detergents, anti-knock agents, and synthetic insecticides.

Representative of the older, more slowly growing and hence more stable categories are paint pigments, solvents, and dyes. Fertilizer sales, falling midway between the newer and more dynamic and the older and more slowly growing commodity groups, are continuing to follow an upward course more in line with that of chemical consumption in general. Viewed in the light of Canadian production opportunities, these are important con-



Source: Canada—D.B.S. U.S.—Stanford Research Institute 53-54-55 U.S. Tariff Commission

clusions. If one can assume that the domestic pattern of output will more closely approximate that of consumption on this continent, chemicals required in the manufacture of plastics and drugs and by the oil refineries may continue to show a higher than average rate of increase. The future of chemicals entering into the production of synthetic rubber, fertilizers, and paints, meanwhile, will be conditioned by a more rigid ceiling on over-all North American and domestic sales.

The Changing Structure of the Industry

General

The previous establishment of other types of industry will continue to be of prime importance. Basic chemical production, historically, has followed in the wake of pulp and paper mills, non-ferrous metal smelters, steel plants, gas processing facilities and oil refineries. While such developments are no longer the sole determinant of its growth, there will be no lack of support from this quarter. The up-grading of resources, like uranium and titanium, will call for ancillary chemical operations. This, together with the fact that it will become increasingly economic to process various Canadian forest and mineral resources prior to export, will help give Canadian chemical producers the market opportunities they need for the financing and initial operation of large plants producing chemicals of comparatively low unit value.

From time to time, new facilities will be built which will take advantage of unique resources. Industries, particularly of the electro-chemical variety, will continue to be built to serve the export market. Natural gas production may also attract primary manufacturing industries, only part of whose capacity will be marketed domestically. Usually, however, it will be cheap materials in the form of by-products which will form the basis of these trading relationships. Further integration between the chemical and other export-oriented resource industries will thereby add to the competitive strength of each and, at the same time, bring about a greater measure of processing in this country.

Secondary manufacturing may be an even more dynamic sector in so far as over-all economic growth is concerned. To date, however, its demand for chemicals has been modest as compared to most manufacturing plants in the United States. Many of the partially processed materials, components and sub-assemblies which Canadian manufacturers import have already had incorporated in them a host of chemicals and chemical products which are therefore never required as such in this country. To the extent that the Canadian content of these manufactures grow, the opportunity for chemical production in this country will also increase. Experience has shown that this is a slow process. Indeed, in many major lines—including automobiles

and industrial machinery—there is little to suggest that market growth in this area will be exceptional over the next decade or two.

There are important exceptions. Chemicals for use in food processing, the manufacture of textiles and of rubber and leather products are in large part made in this country. So are many of the materials used by the construction industry. This is largely because the optimum scale of production is much more in line with Canadian requirements.

Every manufacturer is up against the problem of the economic run. Chemical producers, and especially those serving secondary industry, are not alone in this respect. For a long time many processes could not be carried out efficiently, due to this country's limited population and the specialized nature of its markets. Now, however, the break-even point is being reached with regard to more and more chemicals. This is often reflected in Canada's import statistics. Numerous firms, having watched shipments from foreign sources mount steadily for a decade or more, have one after another decided to get into production on their own in this country, as witness the dozens of new plants and the comparable number of new chemical products which have been introduced in Canada since 1950.

Just what are these new lines of production? They include, as we have already seen, the manufacture for the first time of such things as plastics, paint ingredients and chemical fibre intermediates. By and large, these newcomers are outside the field of heavy chemicals. The latter, due to their resource ties and the protection afforded by high transportation costs, are already well established here. Indeed, there are few chemicals in the one-to-five-cents per pound category of which Canada is not today a substantial producer. Rather, it is in the direction of high unit value products, where economies of scale are essential if the competitive strength of more distant producers is to be overcome, that one must look for the production of chemical commodities which are entirely new to this country.

Typical of this trend has been the manufacture recently in Alberta of the versatile plastic, polyethylene. Tetra-ethyl lead at Sarnia is another which falls in this category. Frequent reference has already been made to the possibilities of producing cellulose moulding powders, dye-stuffs and a much wider variety of pharmaceuticals here. No doubt these and many other relatively high-cost lines will be found on the "Made in Canada" list within the next decade or two.

Yet a cautionary note should be struck. The Canadian market for most products is admittedly increasing. Though scattered and unpredictable as to timing, their eventual existence can frequently be taken for granted. What we cannot be sure of, however, is the optimum size of plant and how it, too, will change with time. With automation it will tend to grow along with and, at times, ahead of the market. Imports, under these circum-

stances, will continue to account for a substantial proportion of Canadian chemical requirements.

Import Competition

There has always been a lag between the production of new products in the United States and their production in Canada. For the majority, this has ranged anywhere from five to 25 years. Only in a few instances (and those have been concerned with resource processing, or the manufacture of certain consumer chemicals which have enjoyed both rapid acceptance and a high degree of tariff protection) have plants been built in this country soon after they have been proven commercially feasible elsewhere.

Market size limitations are one cause. Limited research activities are another. The fact that new chemical products are continually being replaced by other and more suitable ones has also had its effect. So, in numerous instances, is the fact that certain segments of the Canadian market can better be served by American plants or by waterborne movements from overseas. Here we have at least two good reasons why Canada's imports of chemicals are unlikely to show a marked decline relative to domestic demand over the next quarter century.

Although Canada possesses most of the raw materials, technical skills and capital resources needed to support a fully integrated chemical industry, a substantial proportion of the nation's requirements have always been purchased elsewhere. The competitive advantage enjoyed by certain foreign producers is a result of the larger scale operations which they can maintain. The cost differential arising from the inverse relationship which usually exists between plant size and unit cost of output is accentuated in the case of the chemical industry by a high ratio of fixed to variable costs. Production frequently has to be maintained at or above 80% of capacity in order that these enterprises may break even. This inherent disadvantage is further reinforced by the high distribution costs needed to supply widely-scattered Canadian consumers from a single plant.

A series of special circumstances has, in the case of most industrial chemicals now made in Canada, enabled domestic producers to overcome the sort of competiiton which is continually being offered by chemical manufacturers in the United States. For example, large-scale, low-cost plants catering to export markets, either directly (fertilizers) or indirectly through the natural resource industries (chlorine), have been constructed. In other cases, the availability of low-cost raw materials (by-product sulphur), import duties (paints) or high freight charges (caustic soda), have enabled chemicals to be produced domestically rather than imported in increasing amounts year after year.

Most of these special advantages apply to the heavy inorganics and as a result, Canada became largely self-sufficient in respect to these bulk chemicals by the end of World War II. More recently, however, the emphasis has been shifting to the organics. Petrochemical sources have become popular, especially in the servicing of many secondary industry and consumer-chemical requirements. They have, at the same time, accentuated the problem of the economic run. Rarely can one such organic chemical be produced by a simple one or two-step process. Half a dozen co-products and by-products usually result from such an operation. Each, in turn, must be sold, and sold to some advantage, if the over-all operation is to be profitable. To be economic, it therefore requires various markets. Often these are secondary industries of an intermediate type which either do not exist, or are in their infancy, in this country. Because their production—and particularly that of the more highly specialized organics—must await a further rounding out of this vital and yet comparatively undeveloped sector of the Canadian economy, many of these increasingly important chemicals will continue to be purchased abroad.

Unfortunately for Canadian producers, the development of the Canadian market is not entirely a matter of increased population and industrial diversification. Geographically, they are located close to a country many of whose manufacturers consider Canada a convenient place in which to dispose of such surpluses as occur from over-expansion and the fluctuations of the United States economy.

Meanwhile, his Canadian counterpart is prevented from sharing in much of this North-South trade by an effective tariff barrier in the United States. As long as this situation continues, intermittent import flows of this character will add appreciably to the volume of chemical products entering Canada.

Over time, imports have been falling relative to Canadian requirements. They supplied up to 37% of Canadian needs in the last half of the 1920's; 30% in the late 1930's and around 25% in the 1950's. (See chart entitled Chemical Imports as a Percentage of Consumption, 1926-1955.) For the various reasons enumerated above, this trend in the direction of national self-sufficiency is expected to be arrested somewhat. Tentatively, figures of 23% and 20% have been selected for the years 1965 and 1980.

Export Possibilities

There is evidence that, given certain resource and geographical advantages, firms here can operate successfully by integrating their domestic and export sales. Low-cost hydro-electric power has made it possible to do this in the case of some vinyl resins and other carbide chemicals. Low-cost electricity and raw materials and low foreign tariffs have allowed fertilizers to move out in volume. Similar headway is being made in respect to petro-

chemicals. Synthetic rubber, beginning during World War II, and more recently cellulose acetate and its co-products, have also been manufactured for export.

Western European countries, including Germany, with their lower real wage rates, their great technical competence, their willingness to take soft currencies in payment and the strength which comes from serving a well-protected domestic market, offer a threat to Canada's potential overseas markets which cannot be ignored.

The role which the United States will play is, perhaps, even more important. That country is potentially a very attractive market for many Canadian chemicals. However, with few major exceptions, the duties levied and the administrative practices followed by the United States authorities are such as to make increased North-South trade unlikely in the majority of products. (See Appendix C, A Note on Tariffs.)

American producers, periodically unloading their surplus production elsewhere, will meanwhile continue to be formidable adversaries both at home and abroad.

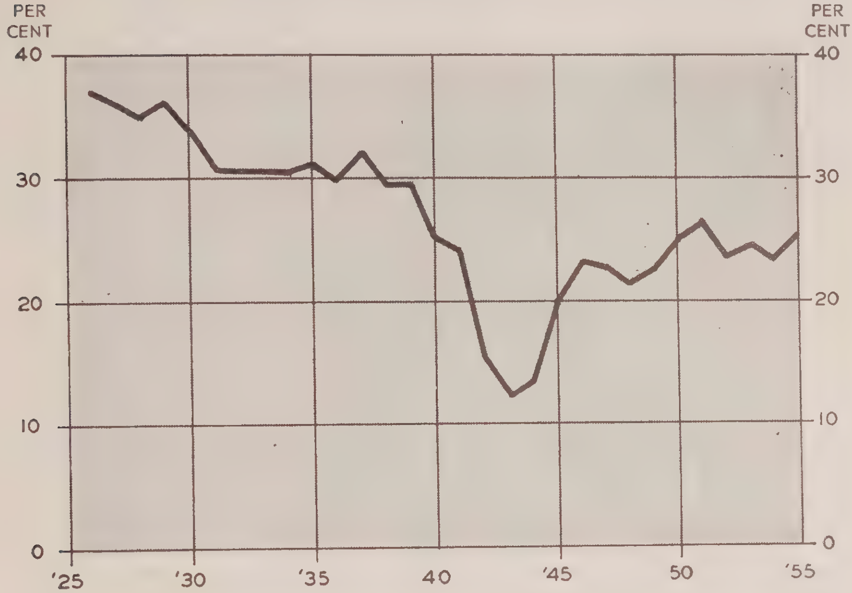
Taking all these factors into account, it looks as if domestic production will continue to increase more rapidly than Canadian exports. The further growth and diversifications of Canadian industry will largely account for that. At the same time, the tendency for chemicals as a group to show a relative decline in world trade may hold true in Canada's case.

We may, in other words, witness a reversal in the role played by exports. From 1933 to 1940 they consistently accounted for about 12% of total Canadian chemical production. Largely as a result of postwar deficiencies, Canada was able to capture a much larger share of the world's export trade. In 1945 over 20% of the nation's output was sold elsewhere. In 1955 it was more like 19%. (See also chart entitled Chemical Exports as a Percentage of Production, 1926-1955.) The opinion of the industry, backed up by our own analysis, is for a decided falling-off in this proportion over the next quarter century. A rough quantification of this trend would place export at approximately 15% of production in 1965 and 12% in 1980.

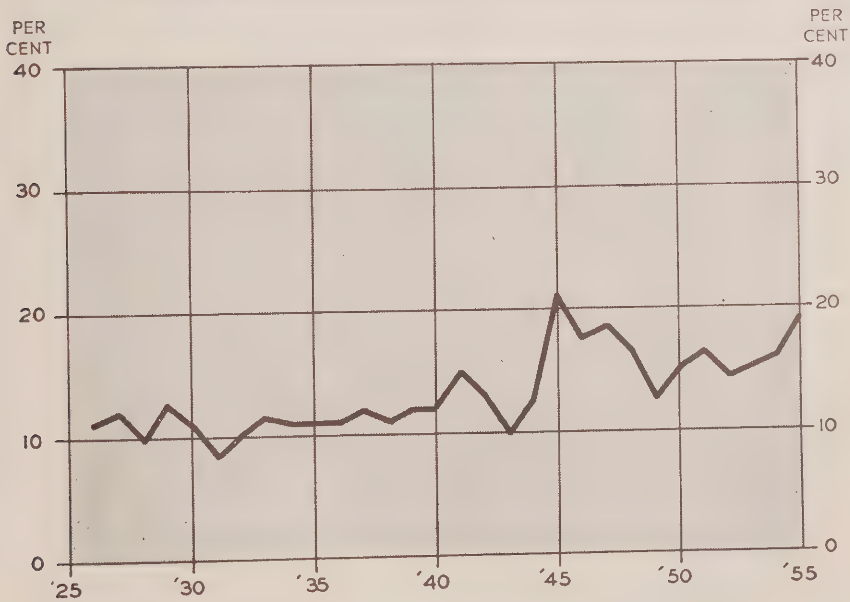
Production Prospects

Even if exports fall off in this way, the Canadian economy will, on balance, be roughly self-sufficient in so far as chemicals are concerned. Striking an average between the various market studies outlined above and employing the suggested trend ratios for imports and exports, we arrive at a forecast of Canadian production which amounts to between $5 and $6 billion in 1980. Equivalent to, say, a fivefold increase, it would be achieved if a 6.5% rate of growth were to be maintained throughout the 25-year period under review.

CHEMICAL IMPORTS AS A PERCENTAGE OF CONSUMPTION, 1926 – 1955



CHEMICAL EXPORTS AS A PERCENTAGE OF PRODUCTION, 1926 – 1955



7

EFFECT ON THE REST OF THE ECONOMY

General

Developments since 1939 illustrate, perhaps better than anything else, the rapid growth and portent of the chemical industry in Canada. Since then its physical plant has more than doubled. More than half of its present sales are products developed since the early 1930's. Chemical firms thus are out-producing most other industries. This is illustrated by the fact that their output has increased nearly 3 times since 1939, compared with 2.4 times for industry as a whole.

The chemical industry has frequently demonstrated its ability to expand over and above the normal rate associated with population growth and purchasing power. One of the reasons for this is that most chemical concerns set aside a much higher proportion of their income for research than do most other industries.[1] Another is that, with inflation, the price of chemicals has risen less than those of most other commodities. These are both influences which we must assume will continue to influence the impact of the chemical industry of Canada's future economy.

A feature of chemical production which is particularly prevalent in the case of the newer organics, is that at almost every stage of manufacture the industry finds itself with more products on its hands than it knows what to do with. Few side products can be readily discarded[2] and the idea is to find an economic way of upgrading these "waste" products into something that can be marketed. Management in chemical firms will, therefore, continually face a sort of chain reaction that keeps piling up new products which have to be sold or in turn transformed again. This is one of the reasons why this industry has no apparent ceiling in the future, and why there appears to be no limit to the products which it will generate.

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[1]It has been calculated that, in the United States the chemical industry spends about 3% of its total sales income on scientific research.

[2]Even the most undesirable by-products can rarely be thrown away, because they may be dangerous to health, cause stream pollution or contaminate the atmosphere.

Chemicals will also have a profound effect upon other industries for another reason. Chemical products and processes tend to be short-lived, due largely to rapid technological change. Minor modifications in one plant may render another obsolete. Indeed, it may bring into being a whole chain of new materials, chemical intermediates and end-products. Some basic commodities such as sulphuric acid will always be necessary. But laboratory and pilot plant research can radically alter the methods of making even the most elementary of substances. Many are obtained as by-products or joint products in any case, and it may well happen that, under a new set of business conditions, the need for certain prime product processes and manufacturing plants will be eliminated entirely.

As chemistry finds greater application in other industries, the rate of obsolescence in the latter will also tend to increase. As in the chemical industry itself, it will therefore result in even greater capital outlays in new buildings, machinery and equipment, and in shorter period write-offs of existing facilities. Continuity will be the keynote; and those firms which are in a position to carry out research and quickly follow up discoveries with the construction of new plants will have the best chance of survival and growth. Frequently it will only be the large companies which are able to do this, especially when general business conditions are not altogether favourable.

As far as price competition is concerned, the chemical industry has always appeared to others as an orderly industry. Cases of price-cutting have been few and far between. This is the nature of the business, and it is due partly to the fact that chemical companies have had plenty of latitude in which to operate without competing directly with each other. Then again, the growing complexity of chemical production puts many of the major firms in the odd position of being both competitors and customers of each other. Heavy investments in plant and equipment, preoccupation with expensive research, and the continual need to adapt its plants and selling techniques to new products, are conducive to competition in its less obvious forms.

One should by no means infer from this that prices of many chemicals will not continue to decline. Costs of production of some of the older inorganics are, of course, approaching an irreducible minimum. But, especially in organics, a new form of competition is emerging. This is coming about more through a multiplicity of sources and processes for arriving at any given chemical, and by the creation of effective substitutes, than by the more obvious old style method of direct price-cutting.

Mention has already been made of the fact that chemical production is conducive to the growth of large corporations. Frequently they are the only ones who can ride the crest of technological progress, paying adequate

attention to long-term trends and refusing to make major decisions on short notice. Often they are selling to a number of smaller industries whose requirements tend to balance each other out. The small new company is rarely so fortunately situated. Even if it can muster the necessary capital to enter one of the more specialized fields, it frequently finds patents and the acquisition of the necessary know-how standing in its way. The path of least resistance, if it persists, is usually to affiliate with, or obtain a licence or agreement from, one of the giant organizations which already dominate the industry.

This trend toward "giantism" is, of course, not confined to chemicals, but it is at least characteristic of chemical processing industries. One need but point to the fact that since the war there has been a marked increase in the formation of concerns in which primary chemical producers have joined hands with other processing firms, usually on a 50-50 basis. They are frequently exploiting some new field, running all the way from basic chemicals to one or more finished products. This has been true, for instance, in the case of petrochemicals including plastics and synthetic fibres.

This proliferation of cross-ties is weaving a new pattern. The fact is that the distinction between chemicals and other processing industries is continuing to disappear. Both groups are fast merging, and may soon be considered corporately as one.

In Canada other examples may be found. The oil industry is now taking a much more active interest in chemical production. Several of the nation's metal smelters and refineries have established divisions turning out chemical products. Basic chemical producers, on the other hand, are reaching out in the opposite direction. Not only are they getting deeper into the related fields of metallurgy and radiation chemistry, but they may eventually be among the largest producers of ferro alloys, titanium and other of the lesser known metals as well.

Some Regional Considerations

Some considerations have been much more important than others in determining the regional pattern of chemical production in Canada. Uppermost in the minds of those men who have decided on the location of plants in this industry have been ready access to raw materials; cheap electric power; proximity to other industries; and the size and diversity of local markets.

Volumes have been written on the subject of industrial location, but few have expressed more than the most general of conclusions relating to the manufacture of chemicals. The following remarks, therefore, are of the nature of a first attempt to reconcile economic theory with some of the opinions held by men who have spent a lifetime in the chemical industry,

and who have themselves carried out or had access to specific studies relating to the competitive advantage of producing chemicals in various parts of the country.

In recent years the industry's development experts have often been asked the question, "Will the ready availability of low-cost raw materials, especially oil and natural gas, cause the chemical industry to gravitate more and more to western Canada?" Their reply is usually a qualified "Yes"; but the affirmative answer which they give is almost always prefaced by statements which encourage one to believe that this shift westward in chemical production will take place much more slowly than is generally expected. Also, they give the impression that it will be much more important in relative than in absolute terms.

Western Canada, and particularly those parts of the country which possess the best oil and gas prospects, still labour under the compound disadvantages of high freight rates and great distances to sizable markets. Unlike the United States Gulf coast, which has managed to attract something like 80% of the petrochemical plants in the United States, they lack cheap water transportation. Therefore, until (a) local demands have grown to the point where they will support an economic plant, or until (b) American tariffs are reduced to the point where chemicals made in western Canada can be marketed in volume in the northwestern United States, or until (c) sizable overseas export markets are acquired, the outlook is not as promising as popular opinion would lead one to believe. The products most likely to surmount these obstacles are those which are vital to agriculture (and hence may gain tariff-free access to adjoining areas in the United States) or are essential to the processing of forest and mineral resources in the western provinces. A few chemicals of unusually high unit value, because they can stand a long rail or road haul to Southern Ontario or Quebec, may also be produced in quantity on the Prairies or in British Columbia.

In the west, the manufacture of fertilizers is already well established, and there has been talk now of new lines such as urea, because, as with other goods used by the farming community, tariffs are no longer operative in this case. Some local demands have been served already. Chemicals for such purposes as the binding of plywood, acidizing of oil and gas wells and the production of commercial explosives are now being made there, largely because of the present and expected abundance of other natural resources. Polyethylene, on the other hand, is a classic example of the type of product which can be made in Alberta and still be priced competitively in eastern Canada. In its case, the savings on fuel and raw material costs have turned out to more than offset the heavy freight tolls which have to be paid in transporting this new chemical from one end of the country to the other. These and other like products, which will be generated

mainly as by-products of such chemical processes as the stripping of sulphur from natural gas, and the treatment of domestic ores and wood pulp, are likely to be typical of the new developments taking place over the next decade or two in this part of the country.

A new factor, and one which is difficult to appraise, is the entry into the transportation field of oil and gas pipelines. By reducing carrying charges, they will improve the competitive position of petrochemical source materials in the principal market areas. Their effect, in other words, will be to modify the drawing power of the fuel source areas in western Canada.

The choice between refinery products, natural gas and natural gas liquids is frequently one of cost—cost as reflected in the price per BTU of these materials when used as a fuel. Improved methods of transportation, by heightening competition between these fuels and coal, will therefore help to reduce the cost penalty which has so far been encountered by the chemical industry in central Canada and on the west coast. Natural gas and its component hydrocarbons appear to be the best source materials for making ethylene and acetylene-based organics, whereas oil refinery products tend to be preferred for the production of some of the more complicated petrochemicals. Also, some products like ammonia and acetylene can readily be made from the more transportable gases such as methane. On balance, therefore, it appears that, though the major expansion in natural gas based petrochemicals will be in the natural gas producing areas, a good deal of new capacity will also be erected at or near the major metropolitan market centres and gateway points where chlorine and other industrial chemicals can be made available at reasonable cost.

A few years ago, the possibility of using pipeline gas as a carrier of the more chemically useful natural gas materials outside Alberta was largely ruled out by that province's export regulations. The chemical content being reduced to negligible proportions, only methane and a little ethane were left. However, the discovery of considerable quantities of wet gas in the Fort St. John area of British Columbia put a different complexion on things. This, together with the tremendous surplus of butane and such fractions which will be produced along with pipeline gas in southern and central Alberta, will necessitate the finding of new outlets, some of them at a considerable distance from the producing fields themselves. Carried along in the "dry" gas stream in the summer months and stripped out in such terminal points as Vancouver and Winnipeg, they may permit a greater dispersal of the industry to take place. Outward tank car and special natural gas liquids pipeline movements may have a similar effect.

Whether the interprovincial or, still more signficant, the international movement of these chemical useful hydrocarbons will be allowed or not is important. To permit their export into adjoining areas of the United States

might well preclude the manufacture of similar products in Canada. They would enter that country in the raw state under the same tariff heading as crude oil. There is no serious obstacle, in other words, to their entry in unmanufactured form into the United States. Canadian-produced petrochemicals, unless they are for use in agriculture, are treated quite differently. Import duties in their case are often prohibitive. Thus it is to small local requirements or to overseas outlets that the industry must look in the launching of new capacity in western Canada. It may be faced, at the same time, with competition from factories built in the United States and using Canadian natural gas and oil-based hydrocarbon materials.

In eastern Canada the situation is different again. There, natural gas is even less likely to be used as a source of raw materials. This is because its price, reflecting the great distances over which it has to travel, will probably make it too expensive for use in the chemical industry. Petrochemical production in Ontario and Quebec, therefore, will continue to expand in and around the major oil refining centres such as Sarnia and Montreal, the only serious limitations being the quantities of gas and light oil fractions which can be made available to chemical firms during the course of these refinery operations.

Few other raw materials have comparable locational effects. This is due largely to their ubiquity, or to the fact that their laid-down cost almost everywhere is small, relative to the value of the chemical production in question. Limestone of a purity sufficient for most processes is found in many places, and sizable salt deposits are either known or are likely to be found in most Canadian provinces, with the probable exceptions of Quebec and Newfoundland. Even there, supplies can be brought in at relatively little expense, either from mines in Southern Ontario, or from the Amherst area of Nova Scotia. A few other minerals such as the potash which has recently been discovered in Saskatchewan, and the naturally occurring phosphates and magnesium compounds found in the Ottawa Valley are less common; but experience shows that they too are likely to be shipped in their native form to plants which use them, rather than cause these chemical industries to migrate in the opposite direction.

Of much greater importance, so far as raw materials are concerned, has been proximity to other industries, particularly those engaged in the early stages of processing the nation's mineral and forest resources. For example, a great deal of Canada's chemical plant is already to be found around the base smelting and refining centres at Trail and Sudbury, the aluminum plants in the Saguenay Valley, and the metallurgical industries to be found in and near Niagara Falls, and at Sorel and Shawinigan Falls in Quebec. Several plants have also been built in recent years, albeit on a much more modest scale, to utilize the by-products of sulphite pulp production, particularly in the Ottawa and Niagara Valley areas. Developments of this kind

will, no doubt, continue to be characteristic of the Canadian scene, new projects such as the Kitimat aluminum plant on the west coast of British Columbia, possible new electro-metallurgical ventures in the Yukon and Labrador, and increased pulp production attracting their share of new chemical processing facilities.

As far as energy is concerned, several qualifications are necessary. The price gap between electricity produced from falling water and that generated by thermal means is steadily narrowing. This means that, in the old line industries at least, Canada's comparative advantage is being reduced with the passage of time. Processes are also being developed which avoid the use of electricity entirely. Depending more on cheap energy in the form of natural gas or oil refinery by-products, they have a tendency to increase the market orientation of chemical production. (See chart entitled The Chemical Industry in Canada.)

Such decisions and, for that matter, the decisions of many other of Canada's future chemical producers, will also be conditioned in large part by the need for efficient means of moving their products to market. This is why sites in the general vicinity of the Great Lakes, or on tide-water on Canada's east or west coasts, will always be held as desirable, and why most of the Canadian Shield country and the rest of the Northwest Territories will, despite their immense power and mineral resources, probably remain outside the orbit of the chemical industry for many years to come.

Market factors, though frequently fundamental in determining the location of this industry, are, at the same time, among the most complex to analyze. Manufacturers of chemicals need to do more than hold down their distribution costs. They also have a vested interest in close liaison with other firms, catering primarily to their special requirements, and serving at the same time as great a number of outlets as possible.

Concerns making the more highly manufactured chemicals, and whose principal markets lie with the country's producers of capital and consumer goods, are quite understandably the most market-oriented. Take Canada's plastics manufacturers as an example. They are, for the most part, to be found in Southern Ontario, or close to Montreal. But one should not overlook those companies normally classed in the heavy chemicals group, whose principal products consist of such goods as industrial solvents and other widely used manufacturers' materials. They too tend to congregate in places where chemicals and chemical processing industries are already well established or are well known to enjoy excellent expansion prospects.

Ready access to markets is the principal, but certainly not the only reason for favouring location in central Canada. By-products must also be disposed of, and this can usually be done most handily in the centres of greatest population. Then there is the need of access to know-how, and the possibility of offsetting old and declining markets with new and growing

ones. It seems inevitable, therefore, that much of Canada's new chemical capacity will continue to grow in and around what are already recognized as the nation's main industrial centres. This line of reasoning seems to support the view that, while the geographical pattern of this industry will change as time goes by, it may not undergo any sweeping change in the next decade or so.

Some idea of the relatively stable regional pattern of chemical production in Canada can be obtained from the following table.

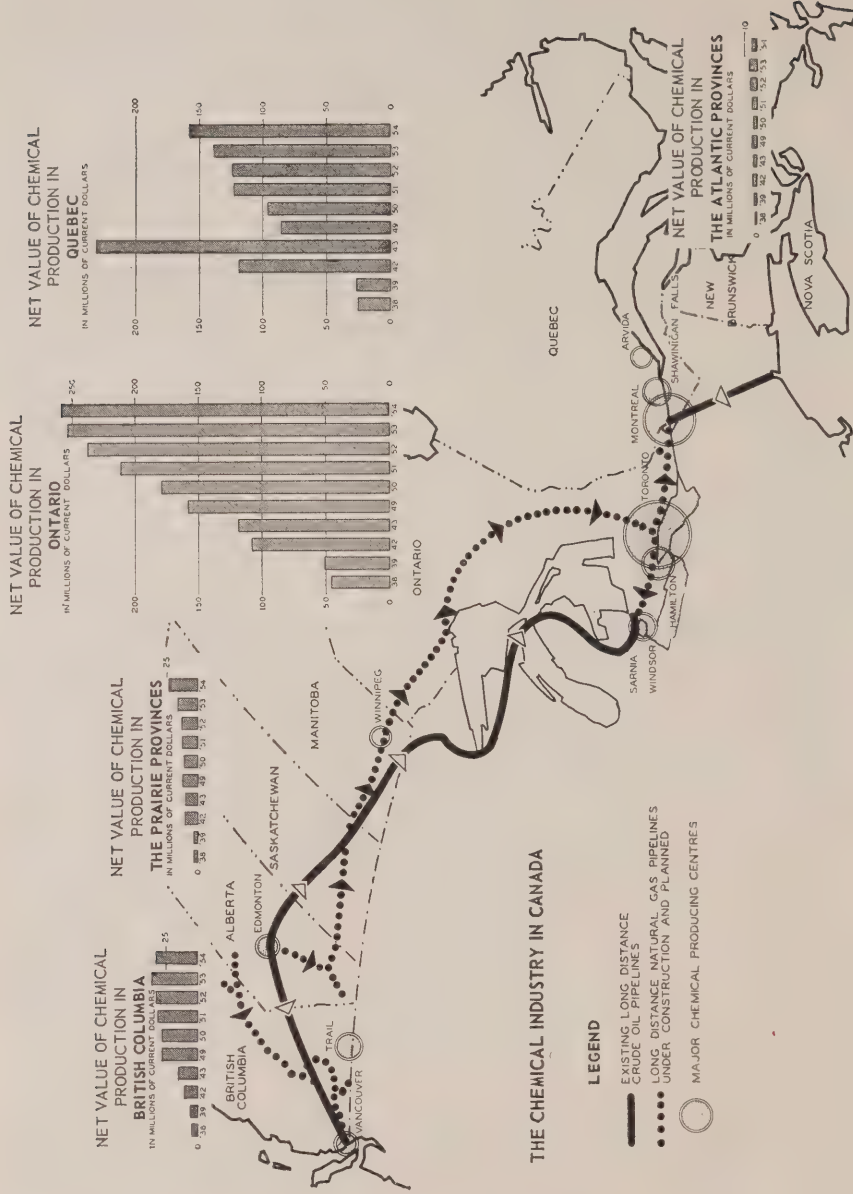
Percentage of Total Employment in the Industry

Region	1929	1939	1950	1955
Maritimes	2	2	1	1
Quebec	35	37	37	41
Ontario	55	52	52	48
Prairies	4	3	4	5
British Columbia	4	6	6	5

Employment

The chemical industry, being for the most part capital intensive, employs relatively few people per unit of output. This is the main reason why it still ranks well below such other industries as food processing and the manufacture of primary textiles in terms of the number of workers which it employs in its own plants. It should be pointed out, on the other hand, that the average worker is better paid than in most other Canadian manufacturing industries. This is true particularly of Canadians employed in plants manufacturing industrial as opposed to consumer end-product chemicals. Another feature is the extent to which this industry depends upon the services of highly skilled personnel. The proportion of research chemists and engineers on the industry's total payroll of 51,000 people is relatively high. Some 8,000 university trained personnel are currently employed by firms classified as being in the Canadian chemical industry. One out of every seven of its employees has an engineering background.

Once established, employment in most chemical plants tends to remain relatively stable. This is true, not only seasonally, but over a period of years. In this respect the chemical industry is one of the least sensitive of all types of manufacturing to changing business conditions. One explanation is to be found in the diversity of products made by each plant. Another derives from the high proportion of capital employed. Large plant maintenance staffs must therefore be retained regardless of the plant's over-all volume of output. Also, because the day-to-day operators' salaries and wages are small relative to total cost, there is a tendency to keep them on the payroll



THE CHEMICAL INDUSTRY IN CANADA

rather than run the risk of losing the services of such highly trained personnel during periods of slack demand.

When preparing over-all estimates of future employment, increasing labour productivity as well as greater output must be taken into account. On the average since 1926, output per man-hour in this industry has risen at an average annual rate of around 2%. Post-war it has ranged between 3% to 3.5%. Since 1951 it has been even higher. Were a compound rate of 3% to be assumed to apply to the industry's activities over the next 25 years, employment would more than double by 1980. Assuming that the industry's real output is five times its present value, the number of jobs provided by the chemical industry might be in the vicinity of 120 thousand 25 years from now.

8

SOME INTERNATIONAL COMPARISONS

INTERNATIONAL comparisons are often interesting. They must, at the same time, be drawn with caution. Structural differences may render industrial comparisons next to meaningless. Also, statistics and the definitions upon which they are based may differ from one country to another. Both of these impediments are present, to a greater or lesser degree, in the case of chemicals. For this reason, the following discussion is limited to Canada and the United States where corporate and other structural similarities exist and where the definitions and procedures used in fact-gathering are similar.

First as to size: the population of the United States is roughly ten times that of Canada. Were both countries equally heavy consumers of chemicals and to a large degree self-sufficient, their ratio of production would also be in the order of ten to one. Neither of these conditions, however, exists. American production, in 1955, was valued at about 18 times the Canadian output of chemicals and allied products. The Canadian industry, meanwhile, was more dependent on export sales. This partially explains the fact that per capita sales were approximately twice as great in the United States. Thus, the total American market—when allowance is also made for population differences—is approximately 20 times the home market available to producers in this country.

Not only is the U.S. market the larger of the two, but both consumption and production are growing more rapidly there. From the late 1930's to the present, production in all industry has increased at a rate of slightly less than 6% per annum in both countries. Chemical production in the United States, meanwhile, has grown at a rate of nearly 9%. Output in this country, as measured by the D.B.S. Index of Chemical Production, has followed a middle course. According to this measure it appears to have lagged well behind that reported by the United States industry since 1947. However, as this measure is based essentially on man-hour inputs it probably understates Canadian achievements in the postwar period.

Using such other statistical indicators as net value added in constant dollars, one finds that production in this country has been moving upward at a rate of something like 8% compounded annually, *i.e.*, at a rate only slightly less than that reported in the United States.

The main reason for this disparity in output has been a proportionately higher level of capital investment in the United States. Outlays on the construction of new chemical plant and the purchase of process equipment, when expressed as a percentage of G.N.P., has been about 40% higher than in Canada. With variations, it has ranged round the 0.25% mark in this country. In the United States, meanwhile, it has been more continuous, higher in relation to G.N.P. (*i.e.* around 0.35%) and geared to a proportionately higher over-all level of economic activity.

The record of progress has, of course, varied both by major category of product and by sub-industry group. The production of organic chemicals (as opposed to the older inorganics) has moved farther ahead in the United States. The emphasis on petrochemical manufacture, in other words, has been greater outside of Canada.[1] As a result, the ratio of output of the better-known, large-volume industrial inorganics is closer to that of population, while with the newer and more varied hydrocarbons and hydrocarbon derivatives it is less so. Currently, Canadian as opposed to U.S. production in the former connection is of the order of one to 14. With the organics this is more in the vicinity of one to 30.

In both countries, industrial chemicals have gained relative to those produced for direct consumption. In 1929, the Canadian ratio of industrial to end-use chemicals was 44:56; that of the United States, 41:59. Since then, even greater emphasis has been placed on the production of basic chemicals required for further processing by other industries. The ratios in 1953 were: Canada, 57:43; the United States, 52:48. Taken in conjunction with what has already been said earlier, it would also appear that industrial chemical production in Canada has followed more closely in step with that of the United States while the manufacture of consumer and allied chemical products has shown a tendency to fall behind the performance south of the International Boundary.

A good deal has been said in this report about the limited size of the Canadian market, the optimum scale of production, and the lack of opportunities for Canadian producers to enjoy many of the economies of scale that exist in the United States. A comparison of the average size of existing plants by sub-industry helps to shed further light on this matter.

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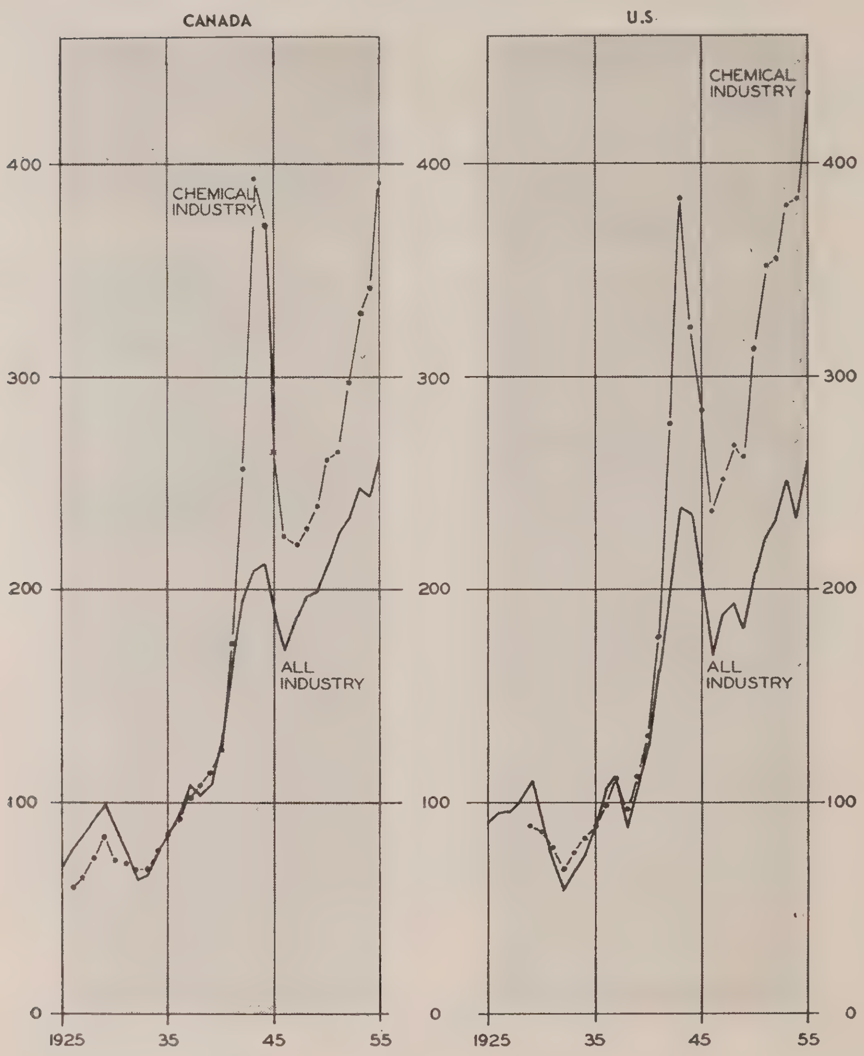
[1]In the United States, petrochemicals comprise 25% by value, of all chemicals produced, whereas in Canada they are closer to 10%.

GROWTH OF CHEMICAL PRODUCTION, CANADA AND U.S., 1925-1955
INDEX 1935 – 39 = 100



In the fertilizers field, the average Canadian plant is the larger of the two. Also Canada's only synthetic rubber plant at Sarnia is bigger (or at least more fully integrated) than the average U.S. factory manufacturing this product. This is consistent with the strong competitive position of Canadian producers in the world's fertilizer and synthetic rubber markets. The typical plant making such basic chemicals as acids, alkalies and salts is similar in both countries. This is true in respect to both employment and value added through manufacture. Canadian industry, in this case, has enjoyed large-volume markets in such primary process industries as pulp and paper and non-ferrous metal smelting and refining. Sales on this account, or advantages stemming from the utilization of by-products from the wood and mineral processing industries have more than offset the size limitation imposed by the servicing of a much smaller domestic market with secondary industry.

In all other instances, and this includes all of the consumer chemicals, the average Canadian plant is smaller, frequently between one-third and one-half of its American counterpart. In paints and varnishes, the Canada-United States size ratio is something like 75 to 100. In respect to vegetable oils, the relationship is more like 60 to 100; in primary plastics 40 to 100; in medicinals and pharmaceuticals 40 to 100; and in soaps and toilet preparations 35 to 100; all others (including miscellaneous chemicals) 30 to 100. Thus, if size is used as our criterion the Canadian industry would appear to be more competitive with respect to industrials chemicals and less so with the production of consumer chemicals and allied products.

This observation is further confirmed by statistics showing the value added per employee in the individual industries. Measured in this way, the performance of Canadian fertilizer and synthetic rubber plants has, for some time, been above that reported in the United States. In respect to basic chemicals, value added per employee in Canada has been about 80% of the United States figure. Comparable performance has also been obtained in factories making soaps and paints. On the other hand, productivity in this country has been lower in factories making other consumer chemicals. Output per worker has continued at about two-thirds of the United States level in industries making medicinals and pharmaceuticals, toilet preparations, primary plastics and miscellaneous chemicals.

It does not appear that in general Canada is closing the gap in so far as productivity is concerned. A statistical analysis reveals that the long-term rate of increase in productivity in the United States chemical industry may be nearly 3.5% per year whereas in the Canadian instance, it is closer to 2%.

These observations have some relevance for the future. It has previously been argued that, with a relative decline in exports and limited opportunities for further processing of Canadian forest and mineral resources, chemical production in this country would become increasingly oriented

toward consumer products. Were this to happen, the presently less productive sectors would be favoured. Productivity, in the broader sense, would rise less rapidly than in circumstances where the economies of scale and resource integration would be allowed full play.

The forecast prepared for this study bears out in some measure the general observations already expressed. The Canadian chemical market is likely to expand to about five times its present size by 1980; a performance which could be surpassed in the United States' chemical economy, for the United States demand forecasts prepared by the Presidents' Materials Policy Commission, the Stanford Research Institute and the Manufacturing Chemists Association suggest a growth in the chemical market there of between 400% and 700% over a comparable period.

9

OBSERVATIONS AND CONCLUSIONS

Chemicals are rightly regarded as one of the nation's "growth" industries. Along with one or two others—notably electronics—it has not only been breaking records but also influencing the rate of expansion in other and widely different areas of industrial activity. This it has done through a happy combination of technological and market research—research carried out on an unprecedented scale; and research which has encouraged both the use of chemical products and the adoption of chemical processes in other and related sectors of the economy.

If chemistry as a science has made mankind less dependent upon a few naturally occurring substances, it has, at the same time, brought industries closer together. Major products, joint products, and by-products are being exchanged in ever increasing volume. Continuous operations, lending themselves more to automation, are also bringing about a greater degree of industrial integration. With this going on, the future of the chemical industry is obviously one which cannot be determined in isolation. Rather, its outlook and that of the mainstream of the Canadian economy are becoming interwoven, inextricably, one with the other.

Growth is a popular word these days. Yet few industries have enjoyed expanding markets to the extent that chemicals have. On this continent, the long-run rate of increase in sales has been of the order of 9% per annum; that is, doubling every eight years. This appears all the more remarkable when it is pointed out that the rate for industry as a whole has been more in the order of 6%; doubling that is, every 12 years. Having been made in constant dollars, moreover, these calculations provide us with a true measure of expansion—not one confused by the reduced purchasing power of the dollar. (See also chart entitled Growth of Chemical Production, Canada and U.S. Index 1935-39 = 100 on page 110.)

Marketwise, the chemical industry has been growing in three quite different directions. It has been growing hand in hand with the so-called chemical process or primary manufacturing industries. It has increased

its sales to many secondary manufacturing concerns. And, finally, it has been getting more and more into the business of producing finished goods—articles like paints and pharmaceuticals—which can be sold directly to the ultimate consumer at the wholesale or retail level.

With all this, chemicals—to an extent rarely encountered in other industries—often finds itself its own best customer. Moving through the various stages of manufacture, its products frequently proceed from one chemical firm to the next. Only when certain lines of activity become so pronounced as to warrant their splitting off into a new statistical category do these internal workings become outwardly apparent. The Canadian chemical industry today is comprised of a dozen or more sub-groups, any one of which may merit major industrial status tomorrow, its place soon to be taken by other and less readily identifiable activities.

The growth process is one thing. The size of the market is often another. Chemical sales in Canada, measured on a per capital basis, are only about half those currently being made in the United States. Taking the Canada-United States population ratio into account, this is the same thing as saying that the American market is about 20 times our own. The gap, furthermore, may be widening. Over the long run, chemical sales in the United States appear to have been moving ahead somewhat more rapidly than they have in Canada.

Why is this? And what are the possibilities, over the next decade or two, of the Canadian industry at least holding its own relative to North American requirements? Should the Canadian economy as a whole manage to expand at a rate comparable with that of the United States, chemicals, it can be argued, should do likewise. By examining more closely the changing market relationships between the chemical industry proper and the major chemical consuming sectors of our national economy, we can obtain some further insight into the future course of events.

Producers in this country, while they participate in a much smaller total market than their American counterparts, also sell more to certain types of users and less to others. They ship a greater proportion of their output to the resource-oriented export industries like pulp and paper, metal smelters and refiners, and primary food processing plants. Percentage-wise, they also sell more chemical end-products for direct consumption. Secondary manufacturing, in the sense of processors and producers of most types of capital goods and consumer durables, buy only modest amounts. What essentially is lacking is the intermediate stage between the primary processing of raw materials and the assembly of the finished article. Canada is not only light in semi-fabrication, but she also lacks the full complement of resource-processing industries. In a fully rounded economy, the latter,

together with the manufacturers of secondary chemicals, are the ones who provide the largest single outlet for basic chemicals.

What we are continuing to witness, particularly in the United States, is the disappearance of chemicals into the production of articles which, in altered and more highly manufactured form, are subsequently imported into this country. Component parts built up from innumerable metal alloys, other mineral substances and organic materials have by then a long history of chemical treatment and change. Even finished goods bought outside Canada may be packaged in and even advertised on media of foreign chemical origin. This helps to explain why, with a comparable standard of living, chemical consumption in Canada continues to lag far behind that of the United States. In other words, a large area of chemical production and consumption is still missing in Canada. Greater integration, made possible by the over-all growth of the economy, should therefore result in a more than proportionate increase both in markets and in basic chemical production here.

With the passing years, Canada's chemical industry can expect to gather further strength from the resource sector. Yet several qualifications must be borne in mind. A growing proportion of Canada's exports—heavily weighted as they will be with iron ore, crude oil, and such industrial minerals as asbestos, gypsum, and potash—will be leaving this country in comparatively unprocessed form. As in recent years, much of our titanium and between one-third and one-half of all our nickel, lead, and zinc production will also be exported prior to chemical treatment, as concentrates. The U.S. market for chemical pulps is nothing like as strong as for the largely mechanically manufactured product—newsprint. Only in respect to natural gas, where the clean-up procedure necessitates a fair measure of chemical processing, can an era of unprecedented expansion be safely forecast.

Meanwhile, chemical methods will supplement if not supplant many of today's operations. This is particularly true in the mineral field where it offers much greater scope for reducing direct labour costs than the older pyro-metallurgical processes. As far as resource conservation is concerned, this will also be a good thing. Not only will major product yields be increased but other metal values and such chemical by-products as elemental sulphur and primary fertilizers will also be produced. Where large complex ore bodies are involved and natural gas can be made available, the possibilities of on-site processing will be enhanced. The local availability of cheap hydro power may have a similar effect in circumstances where electro-chemistry can be used to greater advantage. Otherwise, the tendency for many of these industries to become increasingly market-oriented may have the effect of transplanting these operations outside Canada altogether.

Some of the limiting factors which apply with regard to secondary industry sales have already been discussed. Food processing plants, textile plants, rubber products manufacturers, and the nation's oil refineries can and will buy more chemicals. The process of integration back toward the main source of raw material supply, may, however, be much slower in regard to most other types of manufacturing. Secondary industry, in other words, could continue to grow within the Canadian economy without increasing its chemical purchases relative to those of other lines of activity.

Over the past 20 to 30 years, the rate of growth of sales of end product chemicals on this continent has been trailing a few points behind those of the industrial or basic type. This has been true both in Canada and in the United States—their ratio in value terms was 60:40 in 1929. Currently, in Canada, it is almost the reverse. The value of sales of industrial chemicals in this country is now some 50% greater than those of the consumer variety. Between the late 1930's and early 1950's, it has been primary plastics, synthetic rubber, nitrogenous fertilizers, and the industrial organics which have shown the greatest rates of growth. End categories, like paints, soaps, and drugs, meanwhile have been characterized more by revolutionary changes from within than by value increases which, after all, are a more relevant measure of over-all expansion.

Here, as in most types of secondary industry, we are up against the problem of the economic run. Yet things are becoming more and more complicated. No longer is it a question of matching the output of a large, efficient, single product plant with total Canadian requirements. Instead, multiple product operations have become the rule. The steady shift to organic materials and products has been mainly responsible. New plants utilizing oil or natural gas tend to produce not one but a wide range of chemicals. Frequently, these must be marketed in a dozen different industries; and more than a few of them in widely different parts of the country. Obviously, for chemical production to become increasingly economic, the Canadian economy itself must grow at a rate which will continue to outpace the increasing size and diversification of the average North American chemical plant.[1]

In addition to the problem of scale, we in Canada are also confronted with the time element. In the great majority of cases, chemical production is initiated elsewhere. Only after a lag of ten or 15 years are the majority of new products made here. By then, they have become well-established lines. Indeed, this characteristic is often a prerequisite to their manufacture in Canada. Because of this time lag, the production of many other chemical

[1]The Canadian chemical industry today produces some 300 different chemical products. Over 4,000 organic chemicals are currently being produced in the United States. Their number, furthermore, is being increased at the rate of several hundred annually.

products has often gone full cycle elsewhere. They may well have been introduced, found to be accecptable for a time, manufactured in quantity, and then replaced by other synthetic materials without ever having been manufactured here at all.

No doubt, Canada will be catching up on this process. Yet, as research and development are intensified, they will continue to do two things:

(a) limit the life span of most chemical products; and

(b) decrease the remaining life expectancy of such products as are subsequently manufactured in this country.

To the extent that this lag in production is also reflected in accounting practices, it will mean faster plant write-offs and even safer plant investments than are general among expansionist-minded firms outside Canada. Costs will be higher and the incentive to get into production will be further reduced.

This is the same thing as saying that imports will continue to enter Canada in substantial volume. In the late 1930's, about 30% of Canadian chemical requirements were purchased elsewhere.[2] Currently, the figure is more like 25%. Though the plant building programme which was characteristic of World War II has someting to do with this, the long-run shift toward a greater measure of self-sufficiency is unmistakable. Changing decade by decade, it points toward a further rise in Canadian production relative to domestic requirements.

Canada's export trade cannot be viewed with the same degree of equanimity. The main building blocks for chemical production are fairly evenly distributed throughout the world. Alternative methods—also a product of the laboratory and the pilot plant—have also served to loosen the tie between natural resources and plant location. Some of the newer and more popular materials, particularly oil and natural gas, are readily transportable. Developments in the field of long distance transmission are reducing the cost of moving electricity. Such old time advantages as cheap hydro-electric power have also been minimized by improvements in thermal generation. Nuclear energy and nuclear techniques, if their early promise is fulfilled, will similarly encourage the unmistakable drive toward regional and national self-sufficiency. Chemicals as a group is already showing a decline relative to other commodities entering into international trade. Canada, faced also with the revival of Western European chemical production and continued discrimination against dollar sources of supply, will do well to maintain her present export-output ratio. At the present time, some 19% of Canadian output is sold abroad, as compared with 12% in the late 1930's.[2] These shipments are made up largely of fertilizers, synthetic rubber, primary plastics and textile intermediate chemicals made often in fac-

[2]See Appendix D, Table 24.

tories built for defence purposes and therefore less likely to be duplicated on the basis of commercial demand. Since more of these products may be made elsewhere or encounter increasing competition in world markets, the outlook is for a relative fall in the volume of exports leaving this country, expressed as a percentage of total output.

With all these increases and decreases—expressions alternatively of optimism and pessimism—it may have been difficult for the reader to follow the over-all Canadian position. On balance all that has been said is this: home production should continue to increase at a rate equal to or perhaps well above that of industry generally; imports, while rising may continue to lag somewhat behind domestic requirements; and exports, on the other hand, may become progressively less important in the over-all scheme of things.

Here, then, we have an industry which exhibits many of the strengths and weaknesses of the Canadian economy. Perhaps it has passed through its most difficult years. Yet it is far from being a carbon copy of its opposite numbers in the United States, England, and Western Germany. In becoming more oriented toward the Canadian market, it will be called upon to concentrate a larger part of its production in plants which have historically been uneconomic—uneconomic, that is, in the truly international sense. Unless full advantage is taken of such demands as will allow plants of an optimum size to be built, productivity will suffer. Output per worker will not only lag but will continue to fall behind the North American average.

Among other things, the situation calls for increased market research. Improved material availabilities, further advances in technology, and the leavening influences stemming from an expanding Canadian economy will also help. But greater attention must be paid to the needs and peculiarities of the Canadian market if the chemical industry in this country is to grasp in its stride the numerous opportunities which lie ahead.

THE ROLE OF PETROCHEMICALS

THE MANUFACTURE of petrochemicals (or chemicals based on crude petroleum or natural gas as raw materials) is sometimes referred to as a separate industry. This is something of a misnomer, for identical products can frequently be made from agricultural commodities, forest products or coal. But the term petrochemicals has meaning in that it identifies, in a general way, not only the raw materials from which these chemicals are derived, but also the closely related processes by which they are made. Using plants and equipment which frequently resemble oil refineries, and employing techniques which have only recently been discovered, firms in this new field can be separated from the rest of the chemical industry for purposes of describing their growing importance in the Canadian economy.

In North America today there are some 3,000 petrochemicals in everyday use. Their number, furthermore, is increasing rapidly. Three hundred or more are being introduced every year. In Canada production of these chemicals is modest by comparison. Yet the number of plants which have been built for this purpose since 1950 have already succeeded in expanding their output several fold.

Petrochemical production has a double significance. In the first place, petrochemicals compete effectively with other raw materials. Thus, vegetable products, animal fats and coal tar are no longer exclusive sources of such organic chemicals as oils, detergents and synthetic fibres. Sulphur and ammonia no longer need to be produced from coal or other minerals. Secondly, petrochemicals have made possible entirely new products. Thus the manufacture of synthetic rubber and many of the plastics has been dependent upon chemical research and engineering in respect to oil and natural gas.

Compared to many other organic materials, these fuels are comparatively easy to work with. The organic compounds which they contain can be separated using well-known processes. Frequently the bulk can be sold as useful energy. The chemical source materials, meanwhile, may be of the nature of by-products. Yet, not only are they low-cost but they are also available in considerable volume. Currently only about 2% of all the crude oil and natural gas produced in North America goes into the manufacture of these chemicals. Also the demand for liquid fuels is rising at a comparable rate. Hence, even if the fondest hopes of the chemist are realized, petrochemicals may never account for more than 4% or 5% of the total oil and gas production on this continent.

Yet their progress can be measured in other ways. Petrochemicals currently account for about one-quarter, on a volume basis, of the industrial chemicals produced in the United States and Canada, and 50% of their value. Furthermore, it is expected that on or before 1965 their physical share may have risen to 50% and their dollar value to about three-quarters of that of the entire chemical industry.

Historically the production of organic chemicals began with agricultural products. The first plants engaged in making edible oils and soaps used vegetable matter or animal fat as their *point de depart*. Indeed it was only as a result of the by-product coke oven in steel manufacture that coal began to come into its own. Coal tar started to replace some farm products as a source of raw material from the turn of the century on, and for years continued to meet and inspire most of the new calls which industry was to make on man's ability to produce organic chemicals.

The late 1920's are of historic significance for it was then and only then that oil and gas started to attract attention. A surplus of petroleum products especially in the Gulf coast area of the United States started the ball rolling. Early conservation measures and the fact that markets for wet gas and the lighter refinery fractions were not yet available made their disposal a problem. Among other things the conversion of these petroleum products to industrially useful chemicals seemed like a possible solution and it was with this thought in mind that oil men and chemists sat down together. What they came up with were the first processes around which others have grown up, to cement an ever widening bridge between these originally quite different industries.

In Europe the shoe was on the other foot. Local petroleum resources were small or non-existent, while coal was cheap, abundant and strategically, a much safer starting material. It is little wonder then that even now there is a definite tendency to look to coal as the prop of the future and to regard the production of petrochemicals even in the vicinty of the largest oil refineries as ephemeral and to some extent incompatible with the longer run economics of organic chemical production. (According to a study recently prepared by the Organization for European Economic Co-operation, December 1955, petrochemical production amounted to some 360,000 metric tons in 1955. Projects at present under construction will result in a capacity of 675,000 metric tons by the end of 1957.)

At the outset, petroleum and coal found themselves as allies, both filling in quite distinct fields, often at the expense of agricultural products, as a source of raw material. During the 1920's and early 1930's, cost studies even on this side of the Atlantic seemed to point to oil and gas as the cheapest source of what the chemists call synthetic aliphatic or straight chain compounds, while coal tar could more readily provide the synthetic cyclics or ring compounds. Broadly speaking, this is still the situation, with

oil and gas making much greater headway in the manufacture of such aliphatics as the alcohols and acetone, and coke oven by-products being in strong demand where such cyclics as benzene and benzene's principal derivatives are concerned.

Coal, or more correctly coal tar, being the first raw material to find widespread use, has had a prior claim in the field. It was here in the production of the simpler industrial chemicals where the battle with the petrochemical processes was first joined. It has been in this sector, logically enough, that oil and gas have made their greatest progress. So successful have they become that something like 80% of this continent's organic chemical production is now based on refinery gases, residual oil, natural gas or the natural gas liquids.[1]

At the outset, petroleum and coal were complementary raw materials. Aliphatic chemicals were made from petroleum sources, while aromatic chemicals were prepared from coal tar, supplemented by forest and agricultural chemicals. Typical examples are ethylene glycol made from ethylene; benzene, toluene and phenol made from coal; cellulose from wood; and alcohol, glycerine and soap from agricultural products. Competition between the different types of raw materials began slowly, and only developed sharply during World War II. A critical shortage arose in the supply of toluene for TNT and benzene for synthetic rubber. Since the supply of benzene and toluene was relatively inelastic, being tied to steel and manufactured gas production, the petroleum industry stepped in with processes for the conversion of certain of its feedstocks to aromatics. Since the war the demand for aromatics has continued to stay above the coke and steel industries' output, and this situation is likely to continue.

Wartime developments led to the next round of petrochemical advances, showing increased competition with other sources of supply. Families of petrochemicals based on two, three and four carbon atoms arose. Chemicals such as alcohol, acetone and acetic acid, formerly made by fermentation or from carbide, found competition from petroleum. Acetylene itself was finally made from methane, and the wheel turned full cycle when acetic acid, acetone and formaldehyde were made by oxidizing natural gas. The old idea that certain chemicals were made from certain raw materials was killed, and a new idea was rife: that any organic chemical can be made from any source of carbon. Proof of the power of this idea has since come with the synthesis of glycerine from propylene and of synthetic natural rubber from synthetic isoprene.

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[1]Natural gas and natural gas liquids currently account for about 40%, and the products of crude oil for about 60%, of North America's total petrochemical production.

Large-scale availability of the basic petrochemical building blocks gave tremendous impetus to the plastics industry. Polystyrene first, then polyvinyl chloride, and now the polyhydrocarbons of which polyethylene is the leader, have climbed rapidly into major production. This in turn has given rise to secondary expansions in plasticizers, modifiers, antioxidants on the one hand and in the development of new techniques for shaping, extruding, making fibres and foams.

Paralleling this there has been a sharp postwar surge in synthetic fibres, modifying the older ones, bringing in entirely new ones and extending the process of chemical treatment to the natural fibres themselves.

Unlike the situation with respect to the aliphatics, other demands have to be reckoned with. First and foremost, petroleum cyclics are a valuable constituent of the more expensive gasolines, not erstwhile by-products of little value. There again those which the chemist finds easiest to work with do not occur naturally in crude oil. Initially by cracking and then step by step, they have to be built up synthetically. Many of these processes are well known and some are, indeed, being employed in Canada's larger oil refineries; but there is one big stumbling block—the intermediate materials can frequently bring a higher price as fuel than as a raw material to be used in the manufacture of chemicals.

Accordingly, the principal economic incentive which has favoured the development of aliphatic petrochemicals is not present in the cyclic field to anything like the same extent. It is really only the growing gap between the supply and demand for cyclics which will pull oil and gas somewhat belatedly into this orbit. Here then is the real reason for thinking that petrochemicals will also share increasingly in this field as well, but this time more by default than by providing a cheaper and more abundant source of raw materials.

Organic chemicals, however, are by no means the only products of petroleum and natural gas. Synthetic ammonia may be produced by combining hydrogen from natural gas or fuel oil and nitrogen from the atmosphere. It is a major constituent of fertilizers and has as well a wide range of industrial applications including the manufacture of explosives. In the purification of natural gas (and to a lesser extent in the refining of crude oil) unwanted hydrogen sulphide is recovered and converted to sulphur, an element which has already found widespread use in other chemical process industries. Carbon, as carbon black, has long been manufactured by the incomplete combustion of natural gas. Now residual oil is being used increasingly for this purpose, its product being used in ever-growing volume in the paint, storage battery and rubber industries. Thus it would appear

that the petrochemicals, sometimes for supply reasons, but more often for technological and demand reasons, are not only invading the territory formerly reserved for coal and the products of agriculture, but are also taking over markets long regarded as the exclusive property of the non-fuel mineral kingdom as well.

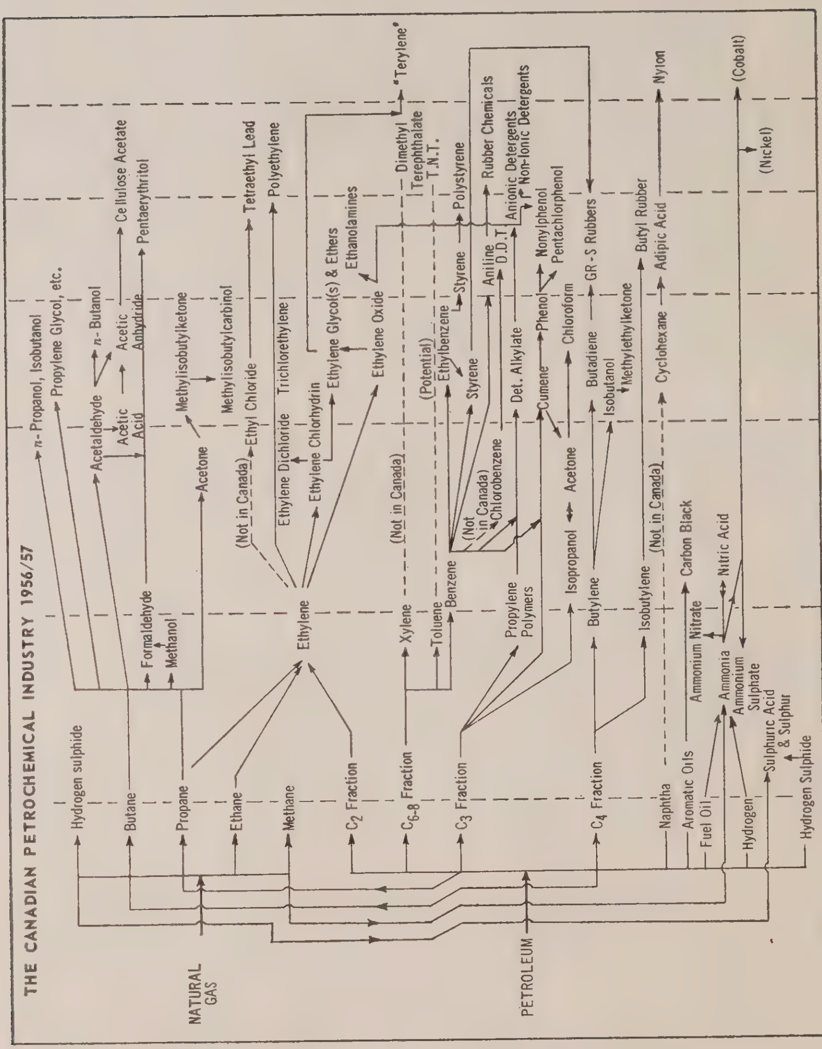
These broad trends and possibilities may have interesting implications for the future. Petrochemicals, it seems, are likely to become more important even to the extent of reducing the use of agricultural commodities in the manufacture of chemicals. Coal tar and its derivatives, meanwhile are likely to be absorbed almost as rapidly as the sale of metallurgical coke allows, supply rather than demand being the limiting factor there. Wood-based chemicals meanwhile are the principal unknowns. According to the experts they have great potentialities. But it may be years or even decades before this source of organic chemicals challenges oil or natural gas in any of the main lines of production in which they are already established.

Note

The accompanying chart has been prepared with a view to illustrating the various sources and degrees of manufacture of the major petrochemicals in Canada. (See chart, The Canadian Petrochemical Industry 1956-57.) All can be made, using different first steps, from crude oil, residual fuel oil, natural gas, or the liquid petroleum gases. These are shown on the left hand side of the chart. Progressing from left to right—that is from the least manufactured to the more highly manufactured products—their cost of production and prices rise. In the area left of the 1¢ line are the raw materials. In the 1¢ range, we find the petroleum fuels.

Ranged between the 1¢ and 10¢ per pound lines, are the more common, big volume petrochemicals; methanol, ammonia, ethylene, acetone, ethyl alcohol, and formaldehyde. From there on, we find the more highly manufactured products like butadiene (for the manufacture of synthetic rubber), detergent alkylate (for soaps); acetic anhydride (for the manufacture of synthetic textiles). Polyethylene is in the 40¢ bracket as is tetraethyl lead. These comparatively high value, low unit volume products can stand greater transportation. This is one of the reasons why the former is already being manufactured in Alberta for sale in eastern Canada. Finally, there are the synthetic fibre intermediates and the chemical fibres themselves. They are in the "over $1" category. Such valuable products as hydrazene, which is priced at around $3, would be away off the chart if it were made in Canada.

In areas where both natural gas and oil are available, the former is preferred for the manufacture of certain organic chemicals; crude petroleum and its products for others. Thus, natural gas and its component hydrocarbons appear to be the best raw material source for methane, ethylene- and acetylene-based petrochemicals. Oil refinery by-product fractions may


THE CANADIAN PETROCHEMICAL INDUSTRY 1956/57
NATURAL GAS
PETROLEUM
Hydrogen sulphide
Butane
Propane
Ethane
Methane
C_2 Fraction
C_{6-8} Fraction
C_3 Fraction
C_4 Fraction
Naphtha
Aromatic Oils
Fuel Oil
Hydrogen
Hydrogen Sulphide
Sulphuric Acid & Sulphur
Ammonia
Ammonium Sulphate
Ammonium Nitrate
Nitric Acid
Carbon Black
Formaldehyde
Methanol
Acetone
Ethylene
Xylene
Toluene
Benzene
Propylene Polymers
Isopropanol
Acetone
Butylene
Isobutylene
n-Propanol, Isobutanol
Propylene Glycol, etc.
Acetaldehyde
n-Butanol
Acetic Acid
Acetic Anhydride
Cellulose Acetate
Pentaerythritol
Methylisobutylketone
Methylisobutylcarbinol
(Not in Canada)
Ethyl Chloride
Tetraethyl Lead
Ethylene Dichloride
Trichlorethylene
Polyethylene
Ethylene Chlorhydrin
Ethylene Glycol(s) & Ethers
Ethanolamines
Ethylene Oxide
(Not in Canada)
Dimethyl Terephthalate
"Terylene"
T.N.T.
(Potential)
Ethylbenzene
Styrene
Styrene
Polystyrene
(Not in Canada)
Chlorobenzene
Aniline
Rubber Chemicals
D.D.T.
Det. Alkylate
Anionic Detergents
Non-Ionic Detergents
Cumene
Phenol
Nonylphenol
Pentachlorphenol
Chloroform
Butadiene
GR-S Rubbers
Isobutanol
Methylethylketone
Butyl Rubber
(Not in Canada)
Cyclohexane
Adipic Acid
Nylon
(Nickel)
(Cobalt)
1
5
10
20
40
80
PRICE – CENTS PER POUND (Car Load Quantities)

be preferred for the production of others. Frequently, however, the choice between natural gas and oil is determined by their relative price. Close to the producing fields, the former is often the more attractive. At a distance, and this applies with particular force to the major market areas in eastern Canada, oil refinery products are the more competitive of the two sources.

Canadian Developments

Though the first petrochemical plants began operating in Calgary in 1941 (ammonia) and in Sarnia in 1943 (synthetic rubber) the industry only began to grow in earnest after 1950. More than 20 plants have commenced operations during the past five years. With a current investment in buildings, equipment and other facilities of around $300 million, it is now turning out 50 or more different petrochemical products. Production has increased approximately fivefold since 1947. From around $24 million it rose to $127 million at the end of 1955. Employment has meanwhile doubled to some 5,000 employees.

Principal Statistics of Selected Firms Comprising the Petrochemical Industry, 1947-55

Year	Number of plants	Number of employees	Salaries and wages $	Cost of fuel and electricity at works $	Cost of materials at works $	Gross selling value of products at works $
			(000's of dollars)			
1947	3	2,366	5,391	2,485	9,379	24,286
1948	3	2,386	5,857	3,036	12,097	30,340
1949	3	2,635	6,904	5,279	15,326	38,462
1950	3	2,731	7,774	6,334	18,595	50,466
1951	3	3,069	10,300	6,867	21,925	64,871
1952	5	3,344	12,156	7,482	24,395	67,187
1953	13	4,124	15,908	8,504	30,103	78,050
1954	13	4,642	19,520	9,955	41,817	99,450
1955	13	4,751	20,425	10,194	48,790	127,104

NOTE 1. No attempt has been made to restrict the above summary to the petrochemical operations of the plants in this group; accordingly, products not petrochemical in nature made at these plants are included as well.

2. Data for this group prior to 1947 are not available as only two plants operated in this period, namely, Consolidated Mining and Smelting Co. of Canada Limited and Polymer Corporation Limited.

The petrochemical industry in this country has exhibited a two-way locational bias; either it has located close by the major petroleum refining centres of Sarnia and Montreal or migrated to the low-cost natural gas fields of western Canada. One development, furthermore, has led to an-

other. At Sarnia, where petrochemical production has been underway for over a decade, products such as ethylene, ethylene glycol, chlorinated solvents, polystyrene, ammonia and carbon black are also being manufactured.

Petrochemicals were first produced in Montreal in 1953 when four plants commenced operations. The major products are organic chemicals: iso-propyl alcohol, acetone, cumene; phenols for use in resins, etc., petroleum refining, and disinfectants; formaldehyde, used as an intermediate in pentaerythritol, and in resins, plastics and drying oils. Glycol and a variety of chlorinated products, using ethylene from refinery gases, were also produced in a plant which is now being extensively remodelled and which will include among its future products polyethylene.

The plants in Alberta manufacture both organic and inorganic chemicals. The two establishments engaged in making organic chemicals are located at Edmonton. One of these plants, perhaps the largest petrochemical plant in Canada, uses propane and butane as raw materials, oxidizing them to produce a wide range of chemicals, including acetaldehyde, acetic acid, formaldehyde, methanol, acetone, propylene glycol, and n-propanol. In addition, the plant is a major producer of pentaerythritol and cellulose acetate, the latter used in the manufacture of acetate fibre and plastics. Polyethylene is produced at another petrochemical plant at Edmonton. A new plant at Fort Saskatchewan produces ammonia for use in the leaching of nickel-copper ores, ammonium sulphate being produced and sold as a by-product. Ammonia is also synthesized from natural gas at Calgary and Medicine Hat. Sulphur is produced from hydrogen sulphides removed in purifying natural gas, and a large increase in sulphur production is assured as further natural gas is marketed.

Plants elsewhere in Canada use imported petrochemicals as raw materials. These include Ontario plants producing formaldehyde and phenolic resins, nylon, and the polyester fibre "Terylene". Additional developments, expected or underway, will augment the production of chemical fertilizer in western Canada, ethylene derivatives in the Montreal area, and will increase the range of petrochemicals produced at Sarnia. The construction of the natural gas pipe line from Alberta to eastern Canada will necessitate stripping plants to remove propane, butane, hexane, and natural gasoline components. These will provide additional petrochemical raw materials in western Canada, and could conceivably encourage the erection of further facilities in eastern Canada based on use of natural gas.

Appendix B

RESEARCH IN CANADA[1]

There are two factors which have largely determined the development of industrial research in Canada. In the first place in a pioneer country primary industries develop first and secondary industries follow later as the population of the country increases. As a result adequate facilities for research in agriculture and in mining developed long before industrial research as such was introduced. This is the normal course of the development of research in a country as it becomes industrialized. The second factor is that because of the proximity of Canada to the United States, and because of the financial relationship between Canadian, American and also British firms, most Canadian plants are essentially branch plants of foreign corporations and research is normally done by the parent organization outside the country. Consequently Canadian industry has been largely dependent on research in the United States and in Britain. The result of this is that, by comparison with the United States or Britain, relatively little research has been done in Canada *by* industrial organizations while a great deal has been carried out by government agencies *for* the industry.

The growth of industrial research in Canada is following the general pattern of the development in the United States, but one war behind. During World War II Canada became a relatively highly industrialized nation with expanded research facilities and highly trained scientific personnel—just as happened in the United States at the end of World War I. There is, however, one striking difference. During the last war, in Canada as in the United States, much research was done at government expense. In the United States, however, most of the war research was carried on by private corporations, which already possessed large and well equipped research facilities.

In Canada, on the other hand, we had few, if any, well equipped industrial laboratories and lacked scientific personnel to carry on research vital to the war effort. This was due primarily to the branch plant situation already mentioned, which meant that Canadian firms were doing no industrial research at all at the beginning of World War II, and thus were not capable of undertaking major research projects during the war. Consequently, practically all the war research in Canada was done by government agencies, principally the National Research Council. The result is that Canada has never gone through a period where there was a large body of industrial research and a small amount in government institutions.

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[1]The following is representative of opinions recently expressed by leaders of public and private research in Canada.

Thus Canada emerged from World War II with highly organized, well equipped and efficiently directed government research laboratories in the form of the National Research Council. The National Research Council in this country is a combination of some or all the functions of the United States National Research Council, the Bureau of Standards, Mellon Institute, plus the work done in the United States by many of the private foundations, and all the armed forces.

Data prepared by Dr. C. J. Mackenzie, formerly president of the National Research Council, show at a glance what has taken place in this country and give an excellent comparison of the growth of research in Canada as compared with that in the United States and the United Kingdom, in terms of dollars spent per capita.

Per Capita Expenditure on Research—in Government and Industry
(dollars)

	Financed by government			Financed by industry			Total		
	1939	1947	1955	1939	1947	1955	1939	1947	1955
U.S.	0.50	5.70	13.70	1.70	3.10	12.40	2.20	8.80	26.10
U.K.	0.40	5.70	11.00	0.30	1.70	11.00	0.70	7.40	22.00
Can.	0.40	2.80	10.20	0.20	0.80	2.00	0.60	3.60	12.20
	Done in labs of govt.			Done in labs of industry			Total in 1935-39 constant $		
U.S.	0.50	2.80	3.10	1.70	6.00	23.00	2.20	5.70	13.00
U.K.	0.40	2.70	3.00	0.30	4.70	19.00	0.70	4.90	11.00
Can.	0.40	2.80	7.20	0.20	0.80	5.00	0.60	2.34	6.10

The trend in these data as far as Canada is concerned is destined to be changed rather drastically in the next decade or so. In the first place, there is a recent trend on the part of the National Research Council to withdraw from certain fields acquired during the war. For example, the work for the armed forces is now largely taken over by the Defence Research Board, and more recently the Atomic Energy Project, originated and developed by the National Research Council, has been absorbed by a newly formed Crown company—Atomic Energy of Canada Limited. The National Research Council will finally revert to its original function of carrying out basic research and special projects for government departments and also for Canadian industry. In the second place, recent industrial growth has been accompanied by a marked upsurge in interest in research among Canadian firms across the country. British and American corporations with branch plants in Canada, who heretofore relied on the central laboratories of the parent companies, have built or are currently building large research establishments, staffed with Canadian scientists for the purpose of tackling problems which are peculiar to their Canadian operations. Furthermore, a number of wholly owned Canadian companies are beginning to see the

necessity for research and are setting up research programmes, and putting in modern facilities in order to meet competition which always arises in a research-minded industry.

Yet the Canadian research effort like many other fields of endeavour, must be tailored to our economic means and requirements. Most of our competitors, principally in the United States, United Kingdom and Germany, operate laboratories employing between 100 and 1,000 scientists, but in Canada very few of the process industries can afford a group of more than about 10 to 15, costing upwards of one-quarter of a million dollars per year to maintain. A team of this size is the absolute minimum for a profitable research group. This not only limits the number of problems a laboratory can undertake, but also seriously confines us to certain types because there are many very attractive fields of research which cannot be, or at least should not be tackled by a group of less than ten scientists.

The synthetic fibres are good examples. It is unlikely that any Canadian company could have developed "Nylon", "Orlon", "Terylene", or such products as G.R.-S. and Polyethylene. It is frequently argued that numbers do not guarantee successful research and development. This is true for fundamental research, where one good scientist with an assistant can frequently make a basic discovery, but here we are talking about the follow-through from test tube to tank car, which requires in some cases a small army of scientists and engineers.

There is still another difficulty—a more important one for the Canadian companies spending relatively large sums of money on industrial research. The same considerations which govern the marketing of chemicals in Canada apply in the case of research. The pot of gold at the end of the rainbow for successful research is much smaller in this country. A company embarks on a research project with a definite purpose in view, usually the development of a new process and/or a new product, which when added to the company's line will contribute to the annual income. The cost of taking the project from test tube to tank car usually runs into several million dollars, and it is a matter of simple arithmetic to show that in order to justify the expenditure a market of a certain minimum size must be available. Only in exceptional cases does such a market exist in Canada.

Furthermore, a chemical company offering a new product of unknown use is at a disadvantage in Canada as it must rely on the research staffs of consumer or secondary industries to find uses for the new material. This type of secondary industry is almost non-existent in Canada, and if the product is a new chemical intermediate it falls on rather barren ground. In the United States on the other hand, chemical corporations frequently spend upwards of $20 million on research, plant and market development on a new product before receiving a cent of revenue, but these companies

proceed in the knowledge that they can create a market and that there are hundreds of chemists and research engineers in the secondary industries who are ready and willing to investigate new uses for the new material. Proof of this may be found in the United States patent records, where there are scores of patents describing new applications for such materials as nylon, polyester resins and acrylonitrile, etc. Most of the difficulties which we are experiencing in the realm of industrial research are intimately associated with the absence in this country of a well-developed secondary manufacture, without which industrial research will never be on an entirely satisfactory basis.

Canadian management must exhibit more faith and confidence in the days that lie ahead than has been the case in the past in this matter of research. If Canada requires further proof of the necessity for research at this stage in her history, it can be found in the annual reports of many of the successful chemical corporations in the United States and Britain, where it is frequently stated that more than 50% of the annual income is derived from processes and products that were developed in the research laboratories in the late '30's or early '40's. There is every indication that Canadian management is rising to the challenge and will continue their research efforts in spite of the difficulties and the risks.

Appendix C

A NOTE ON TARIFFS

General

No report dealing with the Canadian chemical industry would be complete without reference being made to the effect which tariffs have had on its development and present structure. The following few pages have, therefore, been appended to the present study in an attempt to outline the framework of the Canadian tariff and to contrast its workings with that applicable to chemicals entering the United States.

To generalize is to invite controversy. However, to pursue this matter, which is by nature fragmentary and fraught with exceptions, would require much more time and expertise than has been available to our staff. The following statements must, therefore, be regarded as more in the nature of general observations than as conclusions drawn after a lengthy and careful analysis of the chemical tariff and its effects in both countries.

The Canadian Tariff

Canada, in this regard, may be said to be a moderately high tariff country. Yet there are those who would disagree. Executives, speaking mainly about industrial chemicals, would point to such bulk commodities as the fertilizers which have enjoyed duty-free entry in Canada for many years. They could also claim, with justification, that a number of producers of industrial chemicals have managed to get started without any tariff protection at all. This is not to deny that, in the case of many home-produced lines, Canadian import duties are sufficiently high as to be prohibitive. Those affecting certain drugs, soaps, perfumery and like products are often at the other extreme. Indeed, anyone reading through the Canadian tariff schedule is tempted to conclude that the duty on imports entering this country is sufficient to ensure that certain sectors of the home market are reserved for the domestic manufacturer of consumer chemicals.

As far as countries of origin are concerned the Canadian tariff tends to be a preferential one. For instance, the United Kingdom and other Commonwealth countries are charged the lowest applicable rate. Next come what are referred to as the "most favoured nations". Presently these include the world's other major chemical producers, the United States, West Germany, Switzerland, Belgium, France and the Scandinavian countries. The general tariff, which is higher still, no longer applies to any producing countries of note and therefore has little relevance today.

Where chemicals are of a class or kind "not made in Canada", the typical Canadian duty rates somewhat as follows:

(i) British Commonwealth, free;

(ii) "most favoured nations," 5 to 15%;

(iii) all others up to or even above 25% ad valorem.

Again, when they are of a class "made in Canada", the duties in the above order may read: 15%; 20% and 25%, each chemical, however, possessing its own particular tariff schedule. Many of the inorganic chemicals fall into this latter category.

Meanwhile, various tariff items have been established with a view to permitting entry of specific products duty-free or at specially low rates. These regulations were often enacted at a time before manufacture in Canada was contemplated. Some chemicals, either because of their bulk, particular cost advantage or the size of the market, are now produced here in any case.

Mention should be made in passing of the new tariff schedules which now apply to primary plastics. In 1952, following hearings before the Tariff Board, the Board recommended, and the Government accepted, rates ranging from free to 20%.

In the belief that they enjoy less protection than most producers of chemical products made in Canada, manufacturers of plastics are pressing that plastics, per se, be added to the present Reference on Chemicals.

Exceptions exist which, in the main, tend to make the tariff protection enjoyed by the Canadian chemical industry less than would appear to be the case from a more cursory examination of the Canadian tariff. Thus:

(a) The tariff rate varies depending on end use. Concessions may be made when chemicals are sold for specific purposes. For example, use in the manufacture of plastics and synthetic rubber qualifies them for duty-free entry. Chemicals also do not pay a tariff when used for agricultural purposes. As a result the duty on numerous organic chemicals is ineffectual.

(b) Industrial chemicals used by exporting industries are in a special category. Thus, the nation's mines, smelters, refineries and pulp and paper mills are excused, almost entirely, from the payment of duty. Such chemicals as they employ in the processing of raw materials either enter the country duty-free or 99% of the duty is rebated when the resultant products leave Canada. It follows that many of the nation's largest chemical using plants are in a position where

they can refuse to purchase Canadian made chemicals unless the domestic price equals the lowest quotation obtainable abroad.

Various anomalies, leading at times to unequitable treatment also occur in the Canadian tariff. Single chemicals (which have been classified under the Canadian Tariff Item 208 T when imported) are automatically reclassified (to Tariff Item 711) with an increase in duty as soon as the domestic producer is able to supply 10% of the market. Chemical products classified under other tariff headings and dutiable at lower rates do not receive a similar automatic upward adjustment on attaining "made in Canada" status. Thus, the amount of tariff protection which the new product will enjoy is often decided by an historical accident of classification rather than by present economic need.

The United States Tariff

The tariff treatment accorded the chemical industry in the United States differs from that influencing the development of its Canadian counterpart. Duty-free entry has traditionally been limited to fertilizers, several of the more common inorganic acids and salts and such specialized chemicals as must of necessity be obtained abroad. Due to the rapid expansion of chemical production in the United States in recent years such commodities as presently escape American tariff are mainly to be found under the heading of materials for further manufacture in the chemicals and other chemical process industries.

The United States tariff, as it has evolved, has tended to become both outdated and discriminatory. It is divided into two separate lists; the first, a short one, sets out the duty-free items; and the second, including the names of a vast number of chemicals, also lists the duties levied as they enter the country. Rarely does the United States Congress permit the movement of a particular item from one list to the other and, as a result, these categories have evolved with a distinct bias toward protection.

In the duty-free group we find such fertilizer chemicals as can be shipped in bulk. Canadian producers, in taking advantage of this situation, have therefore been able to sell considerable quantities of ammonium sulphate, ammonium nitrate and ammonium phosphate as well as calcium cyanimide fertilizers into adjoining market areas in the United States. A few industrial chemicals of low unit value, such as sulphuric acid which cannot stand transportation over any considerable distance, have also been free to move south across the international boundary. Half a dozen other commodities such as the radium salts and gunpowder, which receive similar treatment, virtually exhaust the United States duty-free list applicable to Canadian production.

The United States tariff structure is also more complex than the Canadian. It is a mixture of specific and ad valorem imposts; some com-

modities being charged under one or other of these headings and the rest under a combination of the two. Usually the total duty paid on each chemical consists of the summation of a specific (cents per pound or gallon) charge and a levy amounting to a percentage of its valuation for shipment.

The United States chemical tariff is, on the average, higher than that imposed by Canada. This is true for two reasons. One is that it tends to apply across the entire gamut of United States chemical production rather than, as in Canada, to a more limited list of products. The other is that they are usually higher in individual instances as well.

The current United States rate structure was originally established by the Tariff Act of 1922 (the Fordney-McCumber tariff). At the outset most chemicals were dutiable at rates equivalent to 25%-60% ad valorem. Some were even higher due to specific levies. Others below this level were granted in respect to low priced inorganics when imported in bulk. As this distinction has continued down to the present, producers of organic chemicals enjoy much greater protection than their older inorganics-producing counterparts.

In recent years the United States rates on numerous chemicals and allied products have been cut by as much as 50%. This action has resulted from the General Agreements on Tariffs and Trade negotiations first at Geneva in 1947, then at Annecy in 1949 and, finally, at Torquay in 1950. At the same time Canada also reduced, or bound at a free or low level certain of her chemical tariffs which were of interest to exporters in the United States and elsewhere.

Because the United States was frequently negotiating downward from a higher level it is claimed that these actions frequently made the Canadian market more accessible to United States producers and, at the same time, left the United States import tariff at a level sufficient to exclude all but a comparatively few Canadian exports.

A comparison of the duties actually paid on chemicals moving either way across the Canada-United States border is of interest. They appear to average out at about 15% of the value of dutiable goods. This could be taken to mean that chemicals can, on the average, surmount a tariff in the order of 15% ad valorem. Higher duties (or a combination of duties with a similar effect) may be assumed to be prohibitive of a continuing trade between the two countries.

Examples of the tariff advantage frequently enjoyed by United States producers can be derived from a comparison of the rates which apply to the products of Canada's latest chemical plants. Ethylene glycol, which enters Canada duty-free or at an m.f.n. rate of 10%, is subjected by the

United States customs to a combination of specific and ad valorem duties amounting to about 35% of its sale price. In the case of phenol, the effective American tariff rate is 37%; three-quarters of Canada's imports of this chemical enter duty-free. Offsetting this to some extent are lower United States duties appended as a result of the GATT trade negotiations. The United States tariffs on certain major Canadian producs such as acetylene black (now 5%), vinyl acetate plastics (now 7½%) and cellulose acetate (12½¢ down from 25¢ per pound) have recently enabled these products to be sold into the United States in some volume.

In summary it might be said that the United States tariff on chemicals is generally higher than the Canadian. Also it is much more comprehensive. This follows partly from the fact that a much wider variety of chemicals are in production in the United States. Meanwhile, new products, prior to their introduction, generally are assured of tariff protection. In Canada this may or may not be the case. It follows, also, that new United States products shipped from the United States into Canada frequently enjoy relatively free access to the Canadian market. Products new to Canada, on the other hand. can rarely be exported in any volume to the United States.

Valuation for Duty Purposes

Rarely is the United States valuation for duty purposes based on the exporting country's invoice price as it is in Canada. Instead, it is usually determined by the highest selling price prevailing in the exporting country (sometimes that pertaining to the retail rather than the wholesale level) little attention being paid to the actual price which the Canadian exporter has been in a position to quote. Thus low cost producers attempting to sell chemicals in the United States are frequently penalized by this practice.

In other cases—coal tar products are an outstanding example—the United States custom valuation is based on the selling price prevailing in the United States, the customs officer employing some such definition as "selling price of any similar competitive article manufactured or produced in the United States". Thus, in the case of numerous petrochemicals, which can also be made from coal tar, the duty may be wholly unrealistic as it can be set against any going price in that country, including that quoted by the least efficient producer. Not only does this allow the United States officials a great deal of discretion but it permits exceptionally high valuations to be placed on Canadian and other foreign produced chemicals being offered for sale in that country.

The Outlook

As the United States tariff on chemicals is unlikely to undergo substantial revision during the course of the next decade or so, the majority of Canadian producers must confine their attention to selling in the Cana-

dian market or exporting overseas. At home they will probably encounter considerable competition from United States and other foreign sources. This will be true particularly of new products and in respect to chemicals consumed by the nation's larger resource-oriented export industries. It follows that, in periods when chemicals are in reasonably good supply in the North American continent, the Canadian chemical industry will continue to concentrate its attention either on the recovery of by-products or on the manufacture of commodities of the consumer chemical type.

In 1955 the Canadian chemical tariff was referred to the Tariff Board for examination and recommendations. Possibly, when the Board's hearings have been completed and its recommendations made public, the Government will deem it advisable to reduce the number of historical and other anomalies which have crept into the Canadian tariff on chemicals over the past half-century. No further assumptions as to changes in policy have been employed in drawing up the various forecasts and other observations described earlier in this report.

Appendix D

STATISTICAL TABLES

1. Total Canadian Production of Chemicals and Allied Products from All Industries, 1920-55, in Current Dollars.
2. Total Canadian Imports of all Chemicals and Allied Products, 1920-55, by Country of Origin, in Current Dollars.
3. Total Canadian Exports of all Chemicals and Allied Products, 1920-55, by Country of Destination, in Current Dollars.
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5. Apparent Consumption of All Chemicals and Allied Products in Canada, 1926-55, in Constant 1955 Dollars.
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7. Supply Analysis of Industrial Chemicals and Allied Products in Canada, 1953.
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19. Canadian Factory Shipments of Paints, Varnishes and Lacquers, (from all Industries), 1953 and 1954.
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22. Capital Expenditures By Chemicals and Allied Products Industries, Canada, (Industrial versus Consumer Chemicals), 1948 to 1956.

Table 1

TOTAL CANADIAN PRODUCTION OF CHEMICALS AND ALLIED PRODUCTS FROM ALL INDUSTRIES[a], 1920-55

Year	Production in millions of current dollars
1920	129
1921	95
1922	96
1923	110
1924	104
1925	110
1926	120
1927	122
1928	135
1929	151
1930	133
1931	114
1932	102
1933	99
1934	115
1935	127
1936	136
1937	160
1938	156
1939	180
1940	223
1941	332
1942	550
1943	826
1944	798
1945	540
1946	451
1947	549
1948	644
1949	652
1950	719
1951	866
1952	887
1953	981
1954	1,021
1955	1,150

[a]Includes production of chemicals and allied products from outside that industry and synthetic fibres after 1938.

Table 2

TOTAL CANADIAN IMPORTS OF ALL CHEMICALS AND ALLIED PRODUCTS[a], 1920-55

(figures in thousands of current dollars)

Year	From U.S.	From U.K.	From other countries	Total all countries
1920	44,895	9,468	4,023	58,386
1925	27,258	4,731	6,553	38,542
1926	31,032	6,201	11,363	48,596
1927	34,091	4,835	9,802	48,728
1928	36,815	5,978	10,381	53,174
1929	39,187	8,141	11,496	58,824
1930	34,740	5,956	12,559	53,255
1931	27,616	5,300	9,505	42,421
1932	22,900	5,945	7,396	36,239
1933	18,792	6,926	8,114	33,822
1934	21,419	7,438	9,631	38,488
1935	22,371	10,867	11,082	44,320
1936	24,599	11,227	11,233	47,059
1937	29,761	14,099	15,127	58,987
1938	26,063	12,201	11,513	49,776
1939	37,307	10,284	10,301	57,892
1940	50,016	10,250	8,852	69,118
1941	65,198	14,488	9,934	89,620
1942	65,750	12,708	9,532	87,990
1943	77,225	11,517	8,334	97,076
1944	85,060	14,902	9,289	109,250
1945	87,215	10,893	10,946	109,054
1946	98,491	11,995	12,443	122,929
1947	117,962	10,372	24,412	152,746
1948	123,879	13,405	17,957	155,141
1949	147,704	14,027	11,756	173,487
1950	170,537	19,021	22,009	211,567
1951	201,164	20,010	38,243	259,417
1952	199,458	15,156	17,424	232,038
1953	225,193	21,685	24,689	271,567
1954	216,008	20,631	19,086	255,725
1955	266,028	26,741	21,449	314,218

[a]Includes *Trade of Canada* series—chemicals and allied products, plus imports of vegetable oils, synthetic rubber, synthetic fibres and sulphur.

Table 3

TOTAL CANADIAN EXPORTS OF ALL CHEMICALS AND ALLIED PRODUCTS[a], 1920-55

(figures in thousands of current dollars)

Year	To U.S.	To U.K.	To other countries	Total all countries
1920	12,969	4,278	—	23,039
1925	9,490	3,680	—	18,167
1926	9,063	3,302	5,085	17,450
1927	8,706	3,941	5,145	17,792
1928	9,814	4,367	4,714	18,895
1929	12,517	4,748	5,159	22,424
1930	9,689	3,348	4,035	17,072
1931	4,811	2,934	3,461	11,206
1932	4,889	2,949	3,489	11,327
1933	5,941	2,928	4,021	12,890
1934	6,520	3,290	4,795	14,605
1935	8,320	3,065	5,429	16,814
1936	8,271	3,899	6,200	18,370
1937	10,253	5,282	6,736	22,271
1938	8,203	5,210	6,748	20,161
1939	10,091	5,778	9,012	24,881
1940	11,182	8,420	12,593	32,195
1941	15,764	26,650	18,191	60,605
1942	29,657	31,259	18,445	79,361
1943	38,338	22,944	27,976	89,258
1944	55,473	25,374	31,777	112,624
1945	62,185	16,624	46,367	125,176
1946	35,817	4,277	41,875	81,968
1947	38,288	8,647	56,371	103,306
1948	44,889	9,367	53,132	107,388
1949	35,384	5,636	44,384	85,404
1950	62,504	6,058	40,117	108,679
1951	70,028	10,682	58,264	138,974
1952	78,255	10,198	43,890	132,343
1953	88,108	11,770	48,433	148,311
1954	88,149	22,236	63,573	175,905
1955	114,020	22,591	83,783	220,394

[a]Includes *Trade of Canada* series—chemicals and allied products, plus exports of vegetable oils, synthetic fibres and total re-exports.

Table 4

RELEVANT PRICE INDEXES FOR DEFLATING CHEMICAL PRODUCTION, EXPORT AND IMPORTS, 1926-55

(1955 = 100)

Year	For Production[a]	For Exports[b]	For Imports[c]
1926	71.2	89.4	55.9
1927	70.0	85.5	57.6
1928	67.9	84.7	54.4
1929	67.9	79.8	53.4
1930	66.0	76.7	56.5
1931	61.7	69.9	53.5
1932	59.7	66.6	53.2
1933	57.9	63.7	51.6
1934	57.8	67.9	49.2
1935	56.4	69.1	49.0
1936	55.6	66.5	49.3
1937	57.1	67.3	49.8
1938	56.7	67.6	48.6
1939	56.7	66.6	49.5
1940	61.3	72.6	63.2
1941	67.0	80.3	67.1
1942	72.3	81.0	71.3
1943	70.8	81.1	68.8
1944	70.6	79.3	70.2
1945	70.1	78.2	71.8
1946	70.0	73.2	76.0
1947	77.2	78.0	88.9
1948	86.0	86.9	91.1
1949	87.7	91.1	91.1
1950	89.2	90.5	93.6
1951	105.8	101.4	106.7
1952	101.8	103.6	99.3
1953	99.3	101.7	99.6
1954	99.7	99.9	98.5
1955	100.0	100.0	100.0

[a]Wholesale Price Index, Chemicals and Allied Products, 1935-39 = 100 converted to 1955 = 100; Prices and Price Indexes, D.B.S.

[b]Chemical and Fertilizer Export Price Index, 1948 = 100, *Review of Foreign Trade,* first half of 1954, D.B.S. and *Trade of Canada,* D.B.S. for subsequent years and converted to 1955 = 100.

[c]See [b].

Table 5

APPARENT CONSUMPTION OF ALL CHEMICALS AND ALLIED PRODUCTS IN CANADA, 1926-55

(in millions of 1955 dollars)

Year	Production	Exports	Imports	Apparent consumption
1926	169	19	88	238
1927	174	21	85	238
1928	199	20	97	276
1929	222	28	110	304
1930	202	22	94	274
1931	185	16	79	248
1932	171	17	68	222
1933	171	20	66	217
1934	199	22	77	254
1935	225	25	90	290
1936	245	27	95	313
1937	280	33	118	365
1938	275	30	103	348
1939	317	38	117	396
1940	364	44	109	429
1941	495	76	134	553
1942	761	98	123	786
1943	1,126	110	141	1,157
1944	1,130	142	155	1,143
1945	770	160	152	762
1946	644	112	162	694
1947	711	132	172	751
1948	749	123	170	796
1949	743	93	189	839
1950	806	120	226	912
1951	819	137	243	925
1952	871	127	233	977
1953	988	146	273	1,115
1954	1,027	168	260	1,110
1955	1,150	220	314	1,244

NOTE: See definitions and statistics for production, exports and imports in current dollars in Tables 1, 2 and 3. See also relevant index series in Table 4.

Table 6

GROSS VALUE OF PRODUCTION IN THE CHEMICAL INDUSTRY PROPER[a] BY MAJOR GROUPS, 1926-55

(thousands of current dollars)

Year	Acids, alkalies & salts	Ferti-lizers	Primary plastics	Medicinals etc.	Paints & varnishes	Other	Total chemicals
1926	18,526	1,450	—	15,382	22,279	50,864	108,501
1927	17,087	1,844	—	16,249	22,606	53,662	111,448
1928	21,256	2,190	—	17,224	24,704	58,304	123,678
1929	28,022	2,259	—	19,039	27,103	62,122	138,545
1930	20,112	2,505	—	17,769	23,967	55,617	119,970
1931	10,952	4,252	—	18,111	18,536	53,651	105,502
1932	11,357	4,006	—	17,574	14,912	47,430	95,279
1933	12,713	1,166	—	17,064	14,897	46,981	92,821
1934	16,494	1,471	—	19,484	18,618	51,985	108,052
1935	19,013	1,369	—	21,293	20,341	56,558	118,574
1936	18,959	1,636	—	22,252	22,651	61,377	126,875
1937	22,410	10,267	—	15,830	25,531	74,935	148,973
1938	20,477	12,841	—	15,778	24,318	72,725	146,139
1939	23,057	13,165	—	27,184	25,856	70,275	159,537
1940	31,001	15,104	—	29,571	30,109	88,105	193,890
1941	50,109	15,189	—	35,472	40,184	163,447	304,401
1942	65,124	21,140	—	41,983	45,765	327,644	501,656
1943	78,359	27,105	—	50,773	45,068	563,913	765,218
1944	81,323	31,189	—	55,640	49,107	516,310	733,569
1945	67,467	34,506	—	60,331	48,397	267,832	478,533
1946	47,301	49,992	21,240	67,050	56,730	133,975	376,288
1947	59,318	58,784	11,783	70,291	69,912	179,872	449,960
1948	70,600	63,986	16,441	71,714	81,279	275,808	579,828
1949	74,412	67,428	21,022	71,502	82,860	270,174	587,398
1950	87,494	68,997	30,728	76,373	92,999	290,280	646,871
1951	117,823	74,489	39,370	89,249	104,839	350,719	776,489
1952	114,188	78,743	34,639	88,022	107,406	373,564	796,562
1953	127,299	84,354	44,542	93,557	113,248	418,504	881.504
1954	142,002	78,149	58,882	97,396	107,727	451,569	935,725
1955	173,307	92,968	75,501	104,898	120,282	482,492	1,049,448

[a]Excluding chemical fibres and chemicals made by other non-chemical plants.

Table 7

SUPPLY ANALYSIS OF INDUSTRIAL CHEMICALS AND ALLIED PRODUCTS IN CANADA, 1953

(figures in thousands of 1953 dollars)

	Industrial chemicals	Allied products	Total
Production from chemicals and allied products industry proper	462,032	419,470	881,502
Production outside the industry proper	95,853	3,702	99,555
Total production	557,885	423,172	981,057
Imports per trade of Canada chemicals and allied products series only	188,527	33,307	221,834
Other imports	23,672	26,064	49,736
Total imports	212,199	59,371	271,570
Supply	770,084	482,543	1,252,627
Exports per Trade of Canada chemicals and allied products series only	131,500	6,385	137,885
Other exports	3.490	4,715	8,205
Re-exports	1,727	21	1,748
Total exports	136,717	11,121	147,838
Apparent consumption	633,367	471,422	1,104,789
Allied products made in basic chemicals	—5,060	+5,060	—
Revised apparent consumption	628,307	476,482	1,104,789

Table 8

CONSUMPTION ANALYSIS OF INDUSTRIAL CHEMICALS AND ALLIED PRODUCTS IN CANADA, 1953

(figures in thousands of 1953 dollars)

	Industrial chemicals	Allied products	Total
Consumption categories:			
Industrial chemicals	95,069	3,170	98,239
Allied products	54,930	18,791	73,721
Direct consumer use	27,486	263,208	290,694
Industrial uses:			
Agriculture	75,320	—	75,320
Plastics fabrication	20,386	—	20,386
Mining, smelting and refining	32,608	—	32,608
Construction and maintenance	5,300	82,201	87,501
Foods, packaging	46,563	55,944	102,507
Pulp and paper	47,215	—	47,215
Rubber and leather products	59,698	413	60,111
Steel products	11,065	22,142	33,207
Petroleum products	13,924	—	13,924
Electrical products	3,971	5,529	9,500
Textile products	92,639	487	93,126
Wood products	3,342	5,130	8,472
Miscellaneous	38,791	19,467	58,258
Total apparent consumption	628,307	476,482	1,104,789

Table 9

FERTILIZER PRODUCTION IN THOUSANDS OF SHORT TONS OF NUTRIENT CONTENT[a]

Area	1938 - 39 Nitrogen	1938 - 39 Phosphate	1938 - 39 Potash	1949 - 50 Nitrogen	1949 - 50 Phosphate	1949 - 50 Potash	1954 - 55 Nitrogen	1954 - 55 Phosphate	1954 - 55 Potash
North and Central Americas	323	717	317	1,302	2,185	1,007	1,914	2,558	1,900
Europe	1,845	2,381	2,707	1,911	2,782	3,158	3,110	3,369	4,532
South America	272	35	12	320	48	12	316	67	3
Asia	415	341	—	411	269	—	737	438	89
Africa	—	51	37	—	143	—	34	192	—
Oceanic	6	392	—	12	543	—	19	638	—
Total world	2,861	3,917	3,073	3,956	5,970	4,177	6,130	7,262	6,524

[a]Commonwealth Economic Committee and FAO.

Table 10

CANADIAN INTERNAL AND EXTERNAL TRADE IN FERTILIZERS[a]

(in thousands of short tons)

Year	Production: Fertilizer materials	Production: Mixed fertilizers	Total imports[d]	Total exports	Total sales[b] in Canada
1930	221	78	271	200	321
1940	525	303	214	335	347
1945	830	539	171	754	575
1950	1,077	670	337	742	765
1951	1,049	697	371	623	771
1952	1,011[c]	649	400	746	769
1953	1,001[c]	695	433	713	820
1954	940[c]	668	413	709 (42.3)[d]	812
1955	n.a.	n.a.	404	(56.3)[d]	791

[a]D.B.S. *The Fertilizer Industry Annual,* and *Trade of Canada.*

[b]Year ending June 30.

[c]These statistics are not comparable with previous years for two reasons.
(i) Factory shipments data are being collected rather than production.
(ii) Sizable tonnages of calcium cyanamide which are used for non-agricultural purposes have been excluded from fertilizer output data since 1951.

[d]In millions of dollars as only dollar figures are reported for 1955, 1954 is given for comparative purposes.

Table 11

TOTAL APPARENT CONSUMPTION OF MAJOR FIBRES IN CANADA

Total Consumption
(millions of pounds)

Year	Cotton	Wool	Silk	Synthetics	All textiles	Per capita consumption pounds All textiles
1926	136.0	54.3	4.1	4.2	198.5	21.0
1927	155.4	54.5	4.8	6.2	221.0	23.0
1928	155.2	58.2	4.4	8.2	225.9	23.0
1929	154.3	55.7	4.0	10.9	224.9	22.5
1930	127.3	47.9	3.4	14.1	192.7	18.9
1931	111.3	35.3	3.2	10.6	160.3	15.5
1932	103.6	35.4	2.8	9.2	151.0	14.4
1933	128.5	43.0	2.3	11.5	185.3	17.5
1934	142.8	47.4	2.4	12.6	205.2	19.1
1935	140.5	51.7	2.9	15.3	210.3	19.4
1936	150.7	56.7	1.9	16.4	225.7	20.6
1937	168.8	56.4	1.9	20.2	247.4	22.4
1938	141.3	46.6	2.0	18.1	208.0	18.7
1939	172.9	53.6	1.8	22.7	251.0	22.3
1940	220.5	74.9	1.9	26.8	324.1	28.5
1941	230.7	71.8	0.5	34.6	337.6	29.4
1942	260.9	76.8	0.1	33.5	371.2	31.9
1943	246.3	64.5	[a]	32.2	343.1	29.1
1944	215.9	56.0	[a]	44.0	315.9	26.5
1945	199.6	59.5	[a]	49.5	308.6	25.6
1946	215.6	74.7	0.1	44.4	334.9	27.3
1947	250.4	84.6	0.5	59.8	395.3	31.6
1948	218.7	86.8	0.4	61.1	367.0	28.7
1949	224.6	73.9	0.4	69.4	368.4	27.4
1950	245.3	77.7	0.6	82.0	405.6	29.6
1951	244.7	68.0	0.5	95.2	408.4	29.2
1952	203.2	52.9	0.4	97.2	353.7	24.6
1953	209.1	68.8	0.4	102.5	380.8	25.8
1954	197.2	51.5	0.4	91.3	340.4	22.4

[a]Less than 0.05 million pounds.
SOURCE: National Industrial Conference Board (Cdn. Office).

Table 12

ANALYSIS OF SYNTHETIC FIBRES, THEIR BASIC MATERIALS AND COUNTRY OF MANUFACTURE

Category	Group	Main names[a]	Basic materials	Manufactured in
Fibres made from natural polymers	Cellulose	Rayon	Wood pulp, cotton linters	Most countries
	Protein	Ardil	Groundnut protein	United Kingdom
		Vicara	Corn protein (Zein)	United States
		Lanital, Merinova	Milk casein	Belgium, Italy
		Fibrolane	" "	United Kingdom
		Caslen	" "	United States
	Not protein	Alginate	Seaweed	United Kingdom
Fibres made from synthetic polymers (Wholly synthetic fibres)	Polyamide	Nylon 66	Hexamethylene diamine and adipic acid	Various countries[b]
		Nylon 6 (Perlon)	Caprolactam	Germany, Switzerland, Netherlands, etc.
	Polyester	Terylene	Terephthalic acid, ethylene glycol	United Kingdom, etc.
		Dacron	Terephthalic acid, ethylene glycol	United States
	Polyethylene	Reevon, Wynene	Polyethylene	United States
		Courlene	"	United Kingdom
	Polyvinyl (acrylic)	Orlon	Mainly Acrylonitrile	United States
		Acrilan	" "	United States
		X-51	" "	United States
		Pan, Redon	" "	Germany
		Dynel	Acrylonitrile & vinyl chloride	United States
	Polyvinyl (non-acrylic)	Bexan	Vinylidene chloride	United Kingdom
		Saran, Velon	Vinylidene chloride & vinyl chloride	United States, Japan, United Kingdom, etc.
		Rhovyl; Pe Ce	Vinylidene chloride & vinyl chloride	France, Germany, Italy, etc.
		Vinylon	Polyvinyl alcohol	Japan
	Mineral	Glass fibre	Silica sand, alkalis and limestone	Many countries

NOTE: Most of the basic materials of the wholly synthetic fibres are derived from by-products of coal and oil.

[a]The names in this column are mainly trade names; this list is by no means complete.

[b]United Kingdom, Canada, United States, Germany, Japan, France, Italy, Switzerland, Spain, etc.

SOURCE: Commonwealth Economic Committee. *Industrial Fibres*, London, 1955.

Table 13

ESTIMATED PRODUCTION AND PLANNED CAPACITY OF SYNTHETIC FIBRES (EXCLUDING RAYON)

(in millions of pounds)

	1950	1951	1952	1953	1954	Planned capacity[b] 1955	1956
United Kingdom							
Nylon	10	10	11	11	20	30	(40)
Terylene	—	1	1	1	1	11	22
Ardil			4	5	7	20	20
Fibrolane				1	2	(5)	(5)
United Kingdom Total	10	11	16	18	30	66	87
Canada							
Nylon and others	5	6	7	10	10	15	20
United States							
Nylon)		125	145	170	175	250	320
Dynel)		4	4	5	7	25	25
Saran)		9	18	20	35	35	35
Orlon)	145	3	5	5	4	20	20
Acrilan)		8	14	18	26	40	48
Vicara)		1	3	4	5	30	30
Dacron (Terylene))		3	4	8	15	35	35
Polyethylene)		12	16	21	22	25	25
Vinyon)		—	1	3	2	(5)	(5)
United States Total	145[a]	165	210	254	291	465	543
Germany (Fed. Rep.)							
Perlon and others	2	7	9	12	15	20	25
Japan							
Amilan (including nylon)	—	1	2	5	10	21	24
Vinyl fibres (Vinylon, etc.)	1	9	12	10	11	30	50
France							
Nylon)	5	7(	6	8	9	14	20
Others)		(	1	2	3	5	10
Italy							
Nylon	1	2	3	5	7	10	12
Merinova		2	2	4	8	10	10
Others	—	—	—	—	2	—	—
Switzerland							
Nylon and others	—	1	1	2	4	5	5
Netherlands							
Nylon and others	1	1	1	2	3	3	4
Total	170[a]	212	270	332	403	664	810

[a]Including glass fibre in United States (40 million lbs. in 1951) which has been excluded elsewhere in this table.
[b]By end of year.
SOURCE: Commonwealth Economic Committee. *Industrial Fibres*, London, 1955

Table 14

WORLD PRODUCTION OF INDUSTRIAL FIBRES

(in millions of pounds)

	1938	1949	1950	1951	1952	1953	1954[a]
Apparel fibres							
Cotton[b]	14,244	15,381	14,823	17,975	18,765	19,239	18,144
Wool (Apparel)[bc]	1,675[d]	1,835	1,892	1,904	2,059	2,065	2,100
Rayon yarn	997	1,644	1,936	2,129	1,844	2,096	2,054
Rayon staple fibre	934	1,071	1,576	1,909	1,743	2,096	2,466
Protein and synthetic fibres	2	110	170	212	270	332	403
Silk	123	46	41	46	55	54	54
Total	17,975	20,087	20,438	24,175	24,736	25,882	25,221
Household fibres							
Wool (Carpet)[bc]	395[d]	418	437	450	467	475	470
Flax	1,772	1,521	1,727	1,929	1,940	1,788	1,714
Total	2,167	1,939	2,164	2,379	2,407	2,263	2,184
Sacking and cordage fibres							
Hemp[e]	2,373	2,077	2,189	2,328	2,411	2,422	(2,450)
Jute	2,813	2,628	3,786	4,489	4,659	2,323	2,424
Total	5,186	4,705	5,975	6,817	7,070	4,745	4,874
Total industrial fibres	25,328	26,731	28,577	33,371	34,213	32,890	30,279
Of which:							
U.S.S.R., China, Eastern Europe	5,047	4,737	6,787	7,168	8,009	7,899	7,654

[a]Preliminary.
[b]Season commencing in year shown.
[c]Clean basis.
[d]Average 1934-35 to 1938-39.
[e]Including an estimate of 200 million lbs. for Indian production of sunn hemp for fibre purposes.
SOURCE: Commonwealth Economic Committee. *Industrial Fibres*, London, 1955.

Table 15

WORLD CONSUMPTION OF THE MAIN APPAREL FIBRES

(in millions of pounds)

	1938	1949	1950	1951	1952	1953	1954
Cotton[a]	14,616	14,022	15,796	15,554	16,125	16,778	16,820[e]
Wool[b]	2,073[c]	2,445	2,681	2,777	2,352	2,614	2,510
Rayon filament yarn[d]	997	1,644	1,936	2,129	1,844	2,096	2,054
Rayon staple fibre[d]	934	1,071	1,576	1,908	1,743	2,096	2,466
Total	18,620	19,186	21,989	21,870	22,053	23,554	23,761

[a]Consumption in seasons (August 1-July 31) commencing in year shown.
[b]Clean basis.
[c]1934-38 average.
[d]Production.
[e]Provisional.
SOURCE: Commonwealth Economic Committee. *Industrial Fibres*, London, 1955.

Table 16

PRODUCTION OF SYNTHETIC RUBBER, 1950-55

(Canada)

Year	Quantity (lbs.)	Selling value at works $
1950	135,521,000	25,413,000
1951	139,578,000	34,648,000
1952	165,694,000	38,470,000
1953	180,263,000	42,129,000
1954	195,819,000	45,509,000
1955	229,735,000	54,278,000

SOURCE: D.B.S. Miscellaneous Chemical Products Industry, Annual.

Table 17

CONSUMPTION OF RUBBER, BY TYPES, 1945-55

(Canada)

Year	Natural thousands of pounds	% of total	Synthetic thousands of pounds	% of total	Reclaim thousands of pounds	% of total
1945	13,198	10.3	80,506	62.9	34,299	26.8
1950	103,305	55.8	50,597	27.3	31,268	16.9
1951	99,404	51.2	59,217	30.5	35,447	18.3
1952	75,043	41.5	75,261	41.6	30,468	16.9
1953	83,956	42.6	80,448	40.8	32,702	16.6
1954	93,129	49.3	67,379	35.6	28,604	15.1
1955	99,282	44.5	90,062	40.4	33,666	15.1

SOURCE: D.B.S. Rubber Products Industry, Annual.

Table 18

CURRENT AND PLANNED PRODUCTION OF SYNTHETIC RUBBER IN WESTERN COUNTRIES OUTSIDE THE U.S. AND CANADA

The United Kingdom and Western Germany have been the only countries outside North America which have operated small synthetic rubber plants in recent years.

The United Kingdom has operated three pilot plants which have had no commercial significance so far. In 1955 Imperial Chemicals Industries, Ltd. built a plant for the production of rubber-like polyesters based on butadiene. The capacity is about 22 million lbs. per year.

Western Germany has produced general purpose rubber in small quantities since 1951. In 1955 output reached 24.4 million lbs.

By 1958, however, Western Europe is expected to have a sizable synthetic rubber industry. Capacities for GR-S and butyl rubber available in the United Kingdom, Western Germany, France and Italy in 1958 are estimated at 350 million lbs. These capacities would compare with forecast requirements for about 500 million lbs. of synthetic rubber in these four countries in 1958. The following projects have been announced.

Country/Ownership	1958 capacity mill. lbs.	Type of rubber	Start-up date
United Kingdom			
International Synthetic Rubber Co. Ltd.	110	GR-S	1958
Western Germany			
Bunawerke Huels G.m.b.H.	100	GR-S ("Buna Huels K")	1958
France			
Societé du Caoutchouc Butyl	45	Butyl	1957
Italy			
Ente Nazionale Idrocarburi (ENI)	67	GR-S	1957

Recently Japan has announced construction of two synthetic rubber plants which will be in operation by 1958. The combined capacities of these two plants will be about 75 million lbs. These capacities may cover Japan's total requirements for synthetic rubber around 1960.

Country/Ownership	1958 capacity mill. lbs.	Type of rubber	Start-up date
Japan			
Mitsubishi Petrochemical	30	GR-S	1958
Eight industrial companies	30	GR-S	
formerly affiliated with	10	Ameripol-SN	
the Furakawa Combine	3	GR-1	
	1.2	Hycar	

Table 19

FACTORY SHIPMENTS OF PAINTS, VARNISHES AND LACQUERS (FROM ALL INDUSTRIES), 1953 AND 1954

(Canada)

	Unit of measure	1953 Quantity	1953 Value of factory shipments $	1954 Quantity	1954 Value of factory shipments $
Paste paints (not including water-paste paints)	lb.	3,691,000	1,002,000	2,627,000	713,000
Water-thinned paints:					
Resin emulsion paints, paste and semi-paste form:					
Interior	Imp. gal.	218,000	688,000	224,000	736,000
Exterior	"	20,000	52,000	29,000	92,000
Cold water paints:					
Interior, casein and protein bound:					
Dry and semi-paste form	Imp. gal.	26,000	55,000	36,000	79,000
Dry powder form	lb.	1,846,000	261,000	1,436,000	198,000
Glue-bound	"	320,000	26,000	302,000	26,000
Exterior:					
Casein and protein bound	"	44,000	6,000	22,000	3,000
Lime or cement bound	"	2,311,000	330,000	2,128,000	294,000
Texture-type water paints	"	1,412,000	122,000	1,385,000	118,000
Latex emulsion paints	Imp. gal.	2,105,000	8,594,000	2,505,000	9,549,000
Calcimines:					
Hot water	lb.	774,000	64,000	420,000	40,000
Cold water	"	693,000	91,000	541,000	70,000
Lacquers:					
Clear	Imp. gal.	1,691,000	4,723,000	1,631,000	4,212,000
Pigmented	"	660,000	2,849,000	648,000	2,747,000
Ready-mixed paints (including asphalt and tar paints)	"	11,824,000	43,009,000	11,446,000	40,868,000
Ready-mixed enamels, oil and synthetic types	"	6,843,000	30,549,000	6,446,000	28,838,000
Stains:					
Oil, spirit, varnish, creosote	"	349,000	925,000	353,000	894,000
Varnishes (including japans, shellac and driers) sold as such	"	3,229,000	9,044,000	3,012,000	8,073,000
Total		—	102,390,000	—	97,550,000

SOURCE: D.B.S. Paints, Varnishes and Lacquers Industry, Annual.

Table 20

PRODUCTION OF MEDICINALS AND PHARMACEUTICALS, 1954

(Canada)

Product	Value of factory shipments
Medicines and pharmaceuticals:	
Registered as patent medicines and sold without all ingredients declared	18,113,729
Antibiotics and preparations:	
Penicillin preparations	2,366,945
Streptomycin preparations	103,784
Penicillin-streptomycin combinations	1,498,223
Other antibiotics and preparations thereof (including penicillin, streptomycin and other antibiotics as well as antibiotic preparations not elsewhere specified	7,070,409
Sex hormones	2,098,008
Sulphonamide (sulpha) preparations with or without other active ingredients	1,318,821
Vitamin preparations in which the principal active ingredients are vitamins	12,354,717
Biologicals and vaccines	4,820,692
Oral antiseptics	774,578
Ethical specialties for human use, not elsewhere specified	29,575,961
All other human medicine	9,018,763
Veterinary medicines	1,684,794
Total	90,799,424

SOURCE: D.B.S. Medicinal and Pharmaceutical Preparations Industry, Annual.

Table 21

PRODUCTION AND FACTORY SHIPMENTS OF SPECIFIED SOAPS AND SYNTHETIC DETERGENTS, 1955

(Canada)

Item	Production	Factory shipments: Quantity shipped	Factory shipments: Value of shipments
	(Pounds)	(Pounds)	$
Hard soaps:			
Bar laundry and household soaps:			
(a) Built	2,031,349	1,952,168	255,606
(b) Not built	16,208,272	15,403,336	2,665,236
Soap chips and flakes:			
(a) In household packages (under 25 pounds)	7,364,517	7,195,469	1,191,025
(b) In bulk (25 pounds and over)	13,987,584	13,177,679	1,476,041
Toilet soaps (except liquid) (when less than 2 pounds each)	37,212,818	37,850,630	10,790,158
Soap powders (granulated, powdered and sprayed, containing more than 25% anhydrous soap):			
(a) In household packages (under 25 pounds)	39,750,685	39,947,400	8,125,542
(b) In bulk (25 pounds and over)	8,935,121	8,824,433	1,131,249
Synthetic detergents:			
Solid (including bars, flake or powder):			
(a) In household packages (under 25 pounds)	111,343,099	111,193,878	30,245,433
(b) In bulk (25 pounds and over)	8,542,523	8,704,559	1,608,973
Liquid:			
(a) Packaged (when in individual containers of less than one gallon)	11,184,361	10,315,408	3,517,507
(b) Bulk (when in individual containers of one gallon or more)	1,422,759	1,411,032	1,422,759
Paste:			
Bulk (when in individual containers of one gallon or more)	788,328	764,728	177,700
Total	XXX	XXX	61,604,406

NOTE: The above figures are for firms which normally account for 95% of the total Canadian production. These figures have not been expanded.

SOURCE: D.B.S. Soap, Washing Compounds and Cleaning Preparations Industry, Annual.

Table 22

CAPITAL EXPENDITURES BY CHEMICALS AND ALLIED PRODUCTS INDUSTRIES[a] CANADA, 1948-56

(In Thousands of Current Dollars)
Products Category

	1948	1949	1950	1951	1952	1953	1954	1955[b]	1956[c]
Industrial Chemicals									
Acids, alkalies and salts	10,884	6,611	5,467	11,498	82,413	78,808	8,608	19,713	43,123
Fertilizers	1,725	1,943	2,012	3,139	7,368	5,632	1,685	8,289	15,275
Primary plastics	7,386	10,535	5,010	5,912	11,997	14,540	2,229	2,557	3,937
Other	14,204	12,828	10,314	32,981	38,010	23,523	31,268	24,479	73,994
Total	34,199	31,917	22,803	53,530	139,788	122,503	43,790	55,038	136,329
Consumer and allied products									
Medicinals and pharmaceuticals	2,424	1,967	1,383	2,806	2,263	2,291	4,841	6,155	6,005
Paints, varnishes and lacquers	2,876	1,599	1,320	2,668	1,998	2,475	3,954	3,948	6,760
Soaps and washing compounds	4,904	7,615	4,457	3,370	3,326	2,692	1,722	1,634	2,914
Other	5,846	3,146	2,481	2,816	2,758	2,828	3,829	2,009	3,488
Total	16,050	14,327	9,641	11,660	10,345	10,286	14,346	13,746	19,167
Total Capital Expenditure	50,249	46,244	32,444	65,190	150,133	132,789	58,136	68,784	155,496

[a]Including Synthetic Fibres
[b]Preliminary
[c]Forecast

Table 23

CHEMICAL CONSUMPTION AS A PERCENTAGE OF G.N.P. 1926-80

(in millions of 1949 dollars)

Year	Chemical consumption	G.N.P.	Chemical consumption as percentage of G.N.P.
1926	187	7,695	2.4
1927	192	8,341	2.3
1928	218	9,031	2.4
1929	208	9,041	2.3
1930	224	8,679	2.6
1931	223	7,571	2.9
1932	187	6,937	2.7
1933	167	6,388	2.6
1934	209	7,127	2.9
1935	240	7,677	3.1
1936	260	8,022	3.2
1937	303	8,088	3.7
1938	288	8,885	3.2
1939	330	9,592	3.4
1940	372	10,977	3.4
1941	473	12,674	3.7
1942	678	15,142	4.5
1943	1,033	15,862	6.5
1944	986	16,466	6.0
1945	656	15,779	4.2
1946	616	15,320	4.0
1947	681	15,479	4.4
1948	705	15,713	4.5
1949	740	16,304	4.5
1950	808	17,325	4.7
1951	818	18,340	4.5
1952	850	19,585	4.3
1953	976	20,332	4.8
1954	975	19,844	4.9
1955	1,091	21,573	5.1
1980	5,456	57,000	9.6
1980	6,219	62,000	10.0
1980	7,093	67,000	10.6

Table 24

IMPORTANCE OF CHEMICAL EXPORTS AND IMPORTS, 1926-80

Year	Exports as percentage of production	Imports as percentage of apparent consumption
1926	11.2	36.9
1927	12.1	35.7
1928	10.1	35.1
1929	12.6	36.2
1930	10.9	34.3
1931	8.6	31.9
1932	9.9	30.6
1933	11.7	30.4
1934	11.1	30.3
1935	11.1	31.0
1936	11.0	30.3
1937	11.8	32.3
1938	10.9	29.6
1939	11.9	29.5
1940	12.1	25.4
1941	15.3	24.2
1942	12.9	15.6
1943	9.8	12.2
1944	12.6	13.6
1945	20.8	19.9
1946	17.4	23.3
1947	18.6	22.9
1948	16.4	21.4
1949	12.5	22.5
1950	14.9	24.8
1951	16.7	26.3
1952	14.6	23.8
1953	14.8	24.5
1954	16.3	23.4
1955	19.1	25.2
1980	12.0	20.0

Table 25

INDEXES OF WHOLESALE PRICES (CANADA) FULLY AND CHIEFLY MANUFACTURED GOODS AND CHEMICALS AND ALLIED PRODUCTS, 1925 TO 1955

Year	Index of wholesale prices, Canada fully and chiefly manufactured goods, 1935 - 39 = 100[a]	Index of wholesale prices, Canada chemicals and allied products, 1935 - 39 = 100[a]
1925	138.0	125.5
1926	133.0	126.0
1927	128.3	123.9
1928	126.3	120.1
1929	123.7	120.2
1930	116.1	116.9
1931	99.5	109.2
1932	92.8	105.7
1933	93.3	102.4
1934	97.7	102.3
1935	94.7	99.9
1936	96.1	98.4
1937	104.4	101.1
1938	103.5	100.4
1939	101.9	100.3
1940	109.9	108.5
1941	118.8	118.6
1942	123.7	127.9
1943	126.9	125.3
1944	129.1	124.9
1945	129.8	124.0
1946	138.0	120.3
1947	162.4	136.7
1948	192.4	152.2
1949	199.2	155.2
1950	211.0	157.7
1951	242.4	187.3
1952	230.7	180.1
1953	228.8	175.7
1954	224.2	176.4
1955	224.5	177.0

[a]D.B.S. Prices and Price Indexes.

Table 26

U.S. WHOLESALE PRICES — CENTS PER POUND

Year	Primary aluminum[a]	Primary copper[b]	Primary steel products[c]	Primary plastics[d]
1925	28.2	14.2	2.68	50.0
1926	27.5	13.9	2.64	49.0
1927	25.8	13.1	2.53	47.0
1928	24.3	14.7	2.50	35.0
1929	24.3	18.2	2.54	33.0
1930	23.8	13.1	2.32	30.0
1931	23.3	8.2	2.20	29.0[e]
1932	23.3	5.7	2.15	28.0[e]
1933	23.3	7.2	2.16	27.0[e]
1934	22.2	8.5	2.42	26.0[e]
1935	19.5	8.8	2.44	25.0
1936	19.0	9.6	2.41	25.0[e]
1937	19.8	13.3	2.84	24.0[e]
1938	20.0	10.1	2.78	23.0
1939	20.0	11.1	2.64	24.0
1940	18.8	11.4	2.65	30.0
1941	16.5	11.9	2.65	32.0
1942	15.0	11.9	2.65	40.0
1943	15.0	11.9	2.65	31.0
1944	15.0	11.9	2.65	30.0
1945	15.0	11.9	2.73	35.0
1946	15.0	13.9	3.00	35.0
1947	15.0	21.1	3.42	38.0
1948	15.7	22.2	3.91	30.0
1949	17.0	19.4	4.21	30.0
1950	17.7	21.5	4.40	32.0
1951	19.0	24.4	4.71	35.0
1952	19.4	24.4	4.82	36.0
1953	20.9	28.9	5.13	35.0
1954	21.8	29.8	5.33	34.0
1955	23.7	37.5	5.61	n.a.

[a]Carload Lots, N.Y., American Metal Market.
[b]Electrolytic, N.Y., American Metal Market.
[c]Composite of Steel Products, American Metal Market.
[d]Synthetic Resins and Plastics, Synthetic Organic Chemicals, U.S. Tariff Commission.
[e]Estimates.

Table 27

U.S. WHOLESALE PRICES — CENTS PER POUND

Year	Synthetic rubber[a]	Natural rubber[b]
1925	—	72.5
1926	—	48.5
1927	—	37.7
1928	—	22.5
1929	—	21.0
1930	—	12.0
1931	—	6.2
1932	—	3.5
1933	—	6.0
1934	—	12.9
1935	—	12.4
1936	—	16.4
1937	—	19.4
1938	—	14.6
1939	—	17.6
1940	—	20.1
1941	—	22.4
1942	50.0	22.5
1943	26.0	22.5
1944	18.5	22.5
1945	18.5	22.5
1946	18.5	22.5
1947	18.5	22.8
1948	18.5	22.0
1949	18.5	17.6
1950	19.0	41.3
1951	25.0	60.9
1952	24.0	38.6
1953	23.0	24.1
1954	23.0	23.4
1955	23.0	39.0

[a]GR—S, Buna S, Synthetic Organic Chemicals, U.S. Tariff Commission.
[b]#1, R.S.S., New York, *Survey of Current Business*, U.S. Dept. of Commerce.

Table 28

U.S. WHOLESALE PRICES, 1935-39 = 100

Year	Raw cotton[a]	Raw wool[b]	Synthetic fibres[c]
1925	180.7	n.a.	n.a.
1926	132.1	n.a.	n.a.
1927	180.7	n.a.	n.a.
1928	171.6	n.a.	n.a.
1929	145.0	131.1	n.a.
1930	88.1	86.7	n.a.
1931	54.1	64.7	n.a.
1932	66.1	53.7	n.a.
1933	99.1	85.2	n.a.
1934	113.8	97.1	n.a.
1935	111.0	87.1	101.8
1936	112.8	111.7	101.8
1937	108.3	121.0	110.7
1938	82.6	81.0	92.9
1939	85.3	99.4	92.9
1940	93.6	113.3	94.6
1941	127.5	129.5	96.4
1942	177.1	144.0	98.2
1943	189.0	152.5	98.2
1944	194.5	153.2	98.2
1945	207.3	151.6	98.2
1946	280.7	132.0	100.0
1947	315.6	151.8	119.6
1948	310.1	149.1	133.9
1949	289.9	152.9	130.4
1950	332.1	206.5	130.4
1951	382.6	301.1	139.3
1952	324.8	172.2	139.3
1953	301.8	176.0	139.3
1954	312.8	171.7	139.3
1955	307.2	146.3	155.3

[a]Exclusive of linters, wholesale, middling, 15/16".
Average 10 Markets, *Survey of Current Business,* U.S. Dept. of Commerce.
[b]Wholesale, Boston, bright fleece, 56's, 58's, clean basis, *Survey of Current Business,* U.S. Dept. of Commerce.
[c]Wholesale, viscose yarn, 150 denier, *Survey of Current Business,* U.S. Dept. of Commerce.

Table 29

INDEXES OF WHOLESALE PRICES, (CANADA), FERTILIZER MATERIALS AND FARM PRODUCTS, 1925 TO 1955

Year	Index of wholesale prices, Canada, fertilizer materials, 1935 - 39 = 100[a]	Index of wholesale prices, Canada, Canadian farm products, 1935 - 39 = 100[a]
1925	130.0[b]	145.0[b]
1926	130.3	144.4
1927	130.3	138.6
1928	121.5	136.3
1929	120.6	140.8
1930	114.9	119.5
1931	107.6	78.9
1932	94.2	65.5
1933	96.2	69.3
1934	98.9	83.5
1935	98.8	89.2
1936	96.1	97.9
1937	96.2	117.4
1938	101.4	102.9
1939	107.5	92.6
1940	111.6	96.1
1941	114.6	106.6
1942	112.9	127.1
1943	109.2	145.4
1944	109.2	155.3
1945	109.2	166.4
1946	110.2	179.5
1947	118.9	192.2
1948	132.5	232.1
1949	141.6	228.7
1950	150.4	236.7
1951	163.1	268.6
1952	175.9	250.2
1953	170.2	221.6
1954	165.6	211.8
1955	163.0	207.2

[a]Prices and Price Indexes, D.B.S.
[b]Estimate.

Table 30

INDEX OF WHOLESALE PRICES, (CANADA), LUMBER, ROOFING MATERIALS, PAINTS; 1925 TO 1955

Year	Price index, Canada lumber and its products used in residential building 1935 - 39 = 100[a]	Price index, Canada roofing materials used in residential building 1935 - 39 = 100[a]	Index of wholesale prices, Canada, prepared paint, 1935 - 39 = 100[a]
1925	110.0[b]	105.0[b]	n.a.
1926	110.9	104.3	n.a.
1927	108.9	103.5	n.a.
1928	114.2	107.3	n.a.
1929	116.7	108.8	n.a.
1930	102.0	103.2	n.a.
1931	86.8	96.2	n.a.
1932	72.7	95.5	n.a.
1933	75.7	96.3	n.a.
1934	90.4	91.5	111.5
1935	86.1	94.7	105.6
1936	96.7	99.3	92.9
1937	112.2	101.7	102.6
1938	100.1	99.7	101.0
1939	104.9	104.1	97.8
1940	119.1	110.4	101.8
1941	139.2	118.7	113.0
1942	153.2	123.4	117.0
1943	171.3	130.1	117.0
1944	188.4	136.0	117.0
1945	191.3	135.5	111.2
1946	202.1	146.2	110.5
1947	242.0	172.3	147.1
1948	305.8	201.6	160.0
1949	322.1	190.5	159.2
1950	349.2	235.4	163.4
1951	425.0	235.8	182.2
1952	415.7	217.7	187.9
1953	410.6	218.6	189.1
1954	400.5	233.4	189.1
1955	409.4	244.5	190.7

[a]Prices and Price Indexes, D.B.S.
[b]Estimate.

Table 31

INDEX OF RETAIL PRICES, (CANADA), DRUGS AND CONSUMER PRICE INDEX, 1925 TO 1955

Year	Index of retail prices, Canada, drugs, 1949 = 100[a]	Index of consumer prices, Canada, 1949 = 100[a]
1925	n.a.	74.6
1926	n.a.	75.9
1927	83.4	74.6
1928	83.4	75.0
1929	83.2	75.8
1930	82.5	75.3
1931	82.2	67.9
1932	82.0	61.7
1933	81.7	58.8
1934	81.3	59.6
1935	81.2	50.9
1936	83.3	61.1
1937	84.6	63.0
1938	85.4	63.7
1939	85.5	63.2
1940	85.4	65.7
1941	86.5	69.6
1942	86.6	72.9
1943	86.6	74.2
1944	84.6	74.6
1945	84.1	75.0
1946	84.1	77.5
1947	88.6	84.8
1948	98.0	97.0
1949	100.0	100.0
1950	101.5	102.9
1951	107.4	113.7
1952	107.9	116.5
1953	108.7	115.5
1954	109.5	116.2
1955	111.0	116.4

[a]*Consumer Price Index*, D.B.S.

Table 32

CHEMICAL PRODUCTION IN CANADA, BY REGIONS, SELECTED YEARS — 1938 TO 1954

(millions of dollars)

	1938		1939		1942		1943		1949	
Region	**Gross**	**Net**	**Gross**	**Net**	**Gross**	**Net**	**Gross**	**Net**	**Gross**	**Net**
Atlantic Provinces	4.4	1.5	4.9	2.0	8.1	3.0	8.2	2.9	12.6	4.1
Quebec	44.7	25.4	48.8	27.1	219.1	119.4	371.8	232.8	167.3	86.1
Ontario	82.2	45.8	90.0	51.3	235.5	108.8	338.2	118.6	330.5	158.4
Prairie Provinces	5.2	2.8	5.3	2.8	19.8	10.3	18.8	9.8	28.1	12.4
British Columbia	9.7	5.1	10.6	5.8	19.1	10.9	28.3	15.4	48.9	27.3

	1950		1951		1952		1953		1954	
Region	**Gross**	**Net**	**Gross**	**Net**	**Gross**	**Net**	**Gross**	**Net**	**Gross**	**Net**
Atlantic Provinces	11.7	3.5	12.3	4.1	13.4	5.1	14.6	5.7	12.2	4.4
Quebec	187.3	95.6	233.7	122.9	232.8	124.8	281.0	138.9	311.8	157.8
Ontario	375.9	179.8	447.3	212.6	466.0	237.8	497.7	253.0	513.6	257.9
Prairie Provinces	22.4	10.9	24.6	12.5	24.9	12.8	29.6	15.3	41.1	22.2
British Columbia	49.6	27.5	58.7	32.0	59.7	33.6	58.5	35.4	56.9	33.8

NOTE: Net value of production is gross value minus cost of fuel, electricity and raw materials used.
SOURCE: D.B.S. Annual General Reviews, Chemicals and Allied Products.

Table 33

EMPLOYMENT IN THE CHEMICAL INDUSTRY PROPER[a] CANADA

1926-55

Year	Acids, alkalies and salts	Ferti-lizers	Primary plastics	Medic-inals, etc.	Paints and var-nishes	Other	Total chemicals
1926	2,040	221	—	2,365	2,484	7,235	14,345
1927	1,881	233	—	2,578	2,563	7,304	14,559
1928	2,517	251	—	2,667	2,881	7,814	16,130
1929	2,897	251	—	2,849	2,851	7,846	16,694
1930	2,409	261	—	2,833	2,835	7,165	15,503
1931	1,694	636	—	2,866	2,780	7,231	15,207
1932	1,679	748	—	2,959	2,658	7,251	15,295
1933	1,891	667	—	3,169	2,540	7,130	15,397
1934	2,289	776	—	3,506	2,859	7,700	17,130
1935	2,627	996	—	3,664	3,060	8,586	18,933
1936	2,966	930	—	3,857	3,124	9,033	19,910
1937	3,359	1,023	—	4,296	3,324	9,966	21,968
1938	2,991	1,232	—	4,270	3,412	9,991	21,896
1939	3,128	1,211	—	4,388	3,540	10,328	22,595
1940	4,002	1,392	—	4,550	3,750	13,988	27,682
1941	6,482	1,748	—	5,026	4,225	36,533	54,014
1942	7,842	1,973	—	5,560	4,507	73,148	93,030
1943	8,045	2,204	—	7,187	4,589	70,263	92,288
1944	7,964	2,226	—	7,600	4,821	59,211	81,822
1945	7,022	2,146	—	8,329	4,979	38,237	60,713
1946	5,338	2,805	3,219	7,670	5,006	13,240	37,278
1947	5,541	3,258	1,060	7,678	5,428	15,526	38,491
1948	5,889	3,169	1,149	7,641	5.558	16,142	39,548
1949	5,861	3,269	1,286	7,658	6,035	17,219	41,328
1950	6,020	3,253	1,392	7,524	5,929	17,357	41,475
1951	7,371	3,218	1,648	7,481	5,859	20,087	45,664
1952	7,591	3,205	1,850	7,457	5,784	21,807	47,694
1953	8,278	3,199	2,160	7,492	5,887	24,991	50,207
1954	8,408	3,049	2,808	7,380	5.719	24,239	51,603
1955	8,642	2.947	2,920	7,494	5,975	23,485	51,463

[a]Excluding any estimate for chemical fibres or other chemicals made outside the chemical industry.

Table 34

UNITED STATES, PURCHASES AND SALES OF THE CHEMICALS AND ALLIED PRODUCTS INDUSTRIES, 1947

Purchases

Industry	$ Millions	Percent
Agriculture	955.0	6.85
Food and kindred products	701.9	5.04
Energy	518.1	3.72
Transportation	385.9	2.77
Paper and allied products	381.2	2.74
Mining	206.0	1.48
Non-ferrous metals	150.0	1.08
Metal products	135.9	0.98
Glass	75.1	0.54
Machinery	69.6	0.50
Iron and steel	58.2	0.42
Lumber and wood	49.9	0.36
Stone, sand, clay and abrasives	46.0	0.33
Printing and publishing	42.9	0.31
Miscellaneous manufacturing	42.0	0.20
Rubber products	38.6	0.28
Construction	26.1	0.19
Plastic products	24.7	0.18
Equipment—professional and scientific	16.0	0.11
Textile mill products	6.7	0.05
Leather and leather products	4.4	0.03
Motor vehicles	3.5	0.03
Electrical goods	3.3	0.02
Transportation equipment	2.8	0.02
Remaining industries	1,194.4	8.57
Total	5,138.2	36.87
Labour and capital consumption	4,177.7	29.98
Government services	772.0	5.54
Sales within the industry	3,847.4	27.61
Grand Total	13,935.3	100.00

Sales

Industry	$ Millions	Percent
Food and kindred products	1,192.5	8.56
Textile mill products	701.7	5.04
Construction	636.8	4.57
Agriculture	635.8	4.56
Rubber products	630.3	4.52
Energy	288.1	2.07
Miscellaneous manufacturing	217.7	1.56
Electrical goods	210.1	1.51
Motor vehicles	173.2	1.24
Personal services	169.4	1.22
Paper and allied products	165.1	1.18
Apparel	139.4	1.00
Leather and leather goods	127.6	0.92
Metal products	102.6	0.74
Printing and publishing	96.8	0.69
Plastic products	93.9	0.67
Transportation	80.2	0.58
Iron and steel	76.7	0.55
Non-ferrous metals	72.3	0.52
Machinery	71.1	0.51
Stone, sand, clay and abrasives	69.4	0.50
Furniture and fixtures	63.2	0.45
Equipment—professional and scientific	52.1	0.37
Glass	46.4	0.33
Lumber and wood	36.2	0.26
Mining	31.2	0.22
Transportation equipment	29.4	0.21
Plumbing and heating equipment	28.4	0.20
Tobacco manufacturing	24.8	0.18
Equipment—agriculture, const., mining	16.8	0.12
Remaining industries	1,164.8	8.36
Total	7,444.0	53.42
Sales within the industry	3,847.4	27.61
Final demand	2,643.9	18.97
Grand Total	13,935.3	100.00

NOTE: All percentage figures are percentages of gross purchases or gross sales.
SOURCE: 1947 Interindustry Relations Study, Bureau of Labour Statistics.

Table 35

PRODUCTION INDEXES

(1935-39 = 100)

Year	United States[a] All industry	United States[a] Chemicals	Canada[b] All industry	Canada[b] Chemicals
1925	91	n.a.	71	n.a.
1926	95	n.a.	80	60
1927	95	n.a.	86	63
1928	99	n.a.	93	74
1929	110	89	99	85
1930	91	87	90	75
1931	75	78	78	73
1932	58	68	66	69
1933	69	76	66	70
1934	75	83	78	79
1935	87	89	86	86
1936	103	99	95	92
1937	113	112	108	102
1938	89	96	102	104
1939	109	112	110	116
1940	125	130	131	126
1941	162	176	165	174
1942	199	278	196	258
1943	239	384	209	395
1944	235	324	212	372
1945	203	284	187	265
1946	170	236	172	225
1947	187	251	188	222
1948	194	267	196	229
1949	181	261	200	241
1950	209	313	212	261
1951	224	352	227	266
1952	232	355	233	298
1953	251	380	248	331
1954	234	383	245	343
1955	260	432	266	391

SOURCE:

[a]Federal Reserve Board bulletins, current issues and U.S. Statistical Abstract. For industrial production, an index on a 35-39 base, began in 1929 and on a 47-49 base in 1925. These were spliced. The 35-39 base stopped in 1950, so this was also spliced to the 47-49 base from 1947 on. For chemical production, the 35-39 base began in 1929 and stopped in 1950 whereas the 47-49 base began in 1947. The 35-39 base was spliced to the 47-49 base beginning in 1947.

[b]*Canadian Statistical Review* D.B.S. and *Canada Year Book* by all industries. For chemicals the net value of chemicals was deflated by the wholesale chemicals price index and converted to an index.

Table 36

CHEMICALS AND ALLIED PRODUCTS INDUSTRIES[a] CANADA AND U.S. FOR SELECTED YEARS: 1921 TO 1953

(U.S. dollars for United States, Canadian dollars for Canada)

Year	United States[b] No. of establishments	United States[b] Total employees No.	United States[b] Total employees Earnings	United States[b] Production workers No.	United States[b] Production workers Earnings	United States[b] Value added by manufacture	Canada[c] No. of establishments	Canada[c] Total employees No.	Canada[c] Total employees Earnings	Canada[c] Production workers No.	Canada[c] Production workers Earnings	Canada[c] Value added by manufacture
		('000)	($000)	('000)	($000)	($000)		('000)	($000)	('000)	($000)	($000)
1921	7,970	274	362,552	208	213,331	825,117	471	13	16,276	9	9,359	46,138
1923	8,016	334	450,483	259	279,033	1,168,069	482	15	18,734	11	10,674	54,158
1925	7,911	n.a.	n.a.	256	289,596	1,303,849	518	14	18,168	10	10,064	54,325
1927	8,361	342	482,093	273	311,819	1,456,851	569	15	18,966	11	11,086	61,203
1929	8,933	373	535,710	300	342,165	1,704,689	565	17	22,966	12	13,344	79,646
1931	8,098	n.a.	n.a.	244	254,418	1,348,032	629	15	21,167	10	10,840	62,024
1932	7,108	298	300,901	250	212,945	1,109,316	706	16	18,962	10	8,944	55,884
1935	7,978	n.a.	n.a.	289	276,332	1,346,277	742	19	23,950	12	11,530	66,651
1937	8,999	n.a.	n.a.	297	358,256	1,706,933	765	22	28,806	15	15,010	80,240
1939	8,419	n.a.	n.a.	268	332,751	1,784,696	819	27	36,233	19	19,391	97,068
1947	9,386	615	1,857,453	453	1,203,614	5,197,894	1,049	46	90,670	34	60,435	255,921
1949	9,410	593	2,031,806	425	1,276.532	5,719,610	1,040	49	117,454	33	72,659	258,465
1953	10,300[d]	753	3,350,084	525	2,075,236	9,273,345	1,108	57	184,722	38	113,072	491,198

[a]Including synthetic fibres but excluding chemicals and allied products made in other industries. U.S. data from Census of Manufactures, Dept. of Commerce; Canadian data from Census of Industry, D.B.S.

[b]Marine and animal oils excluded to make U.S. data comparable with Canadian data.

[c]Synthetic fibres not included prior to 1939.

[d]1952.

Table 37

PRODUCTIVITY IN THE CANADIAN AND UNITED STATES CHEMICAL INDUSTRIES, 1927 TO 1953

Year	1 Value added current $000	2 Production workers	3 1:2 current $	4 Price index 1949 = 100	5 Value added per production worker constant 1949 $	6 Index of 5 1927=100
			Canada			
1927	61,203	10,923	5,603	81.2	6,900	100.0
1929	79,646	12,331	6,459	77.4	8,345	120.9
1931	62,024	10,398	5,965	70.3	8,485	123.0
1932	55,884	10,206	5,476	65.1	8,412	121.9
1935	66,651	12,222	5,453	64.3	8,406	121.8
1937	80,240	14,699	5,458	65.1	8,384	121.5
1939	97,068	18,616	5,214	64.6	8,071	117.0
1947	255,921	34,210	7,481	88.0	8,501	123.2
1949	258,465	33,106	7,807	100.0	7,807	113.1
1953	491,198	37,752	13,011	113.2	11,494	166.6
			United States			
1927	1,456,851	273,170	5,333	81.0	6,584	100.0
1929	1,704,689	300,413	5,674	79.2	7,164	108.8
1931	1,348,032	244,299	5,518	66.9	8,248	125.3
1932	1,109,316	250,198	4,433	62.3	7,116	108.1
1935	1,346,277	288,898	4,660	66.6	6,997	106.3
1937	1,706,933	296,684	5,753	69.6	8,266	125.5
1939	1,784,696	267,839	6,663	74.0	9,004	136.8
1947	5,197,894	452,528	11,486	107.4	10,695	162.4
1949	5,719,610	424,716	13,467	100.0	13,467	204.5
1953	9,273,345	525,263	17,655	111.5	15,834	240.5

SOURCE: Census of Industry, D.B.S. and Department of Commerce.

Table 38

PRODUCTIVITY IN THE CANADIAN CHEMICAL INDUSTRY, 1939-55

Year	Average hours worked per week[a]	Average employment	Millions man-hours	N.V.P. millions current $	Chemical price index 1955=100	N.V.P. millions $ 1955	Constant $ N.V.P. per man-hour	Index 1955=100
1939	44.7	22,834	53.08	90.0	56.7	158.7	3.00	62.2
1940	47.4	27,940	68.87	105.2	61.3	171.6	2.49	51.7
1941	49.4	54,327	139.56	159.1	67.0	237.4	1.70	35.3
1942	48.6	93,381	235.99	254.1	72.3	351.4	1.49	30.9
1943	47.8	92,681	230.37	381.2	70.8	538.4	2.34	48.5
1944	46.4	82,284	198.53	357.7	70.6	506.6	2.55	52.9
1945	45.0	61,329	143.51	252.9	70.1	360.7	2.51	52.1
1946	43.3	38,012	85.59	208.4	70.0	297.7	3.48	72.2
1947	43.0	39,237	87.73	234.1	77.2	303.2	3.46	71.8
1948	43.3	39,578	89.11	268.8	86.0	312.5	3.51	72.8
1949	43.5	41,328	93.48	288.2	87.7	328.6	3.52	73.0
1950	43.3	41,475	93.38	317.2	89.2	355.6	3.81	79.0
1951	42.9	45,664	101.87	384.0	105.8	362.9	3.56	73.9
1952	41.9	47,694	103.92	414.1	101.8	406.8	3.91	81.1
1953	41.8	50,207	109.13	448.3	99.3	451.4	4.14	85.9
1954	41.4	51,603	111.09	466.5	99.7	467.9	4.21	87.3
1955	41.4	51,463	110.79	534.2	100.0	534.2	4.82	100

[a]Last week in October and November for 1939 to 1944 inclusive. From 1945 year's average. Last week in October 1945 was 45.9.

SOURCE: D.B.S.

Table 39

INTER-INDUSTRY PURCHASES AND SALES OF CHEMICALS AND ALLIED PRODUCTS

(percent of total sales)

Sales Category	Canada 1953	United States 1947
Within chemical industry	16	28
Agriculture	7	5
Plastic products	2	1
Mining and refining	3	1
Construction and maintenance	8	5
Foods and packaging	10	9
Pulp and paper	4	2
Rubber and leather	5	5
Steel products	3	4
Petroleum products	1	2
Electrical products	1	2
Textile products	8	6
Wool products	1	1
Miscellaneous	5	10
Final demand	26	19
Total	100	100

SOURCE: Canada—See statistical analysis in this appendix.
United States—Dept. of Commerce statistical analysis in this appendix.

Table 40

PRODUCTION OF INDUSTRIAL VERSUS CONSUMER CHEMICALS, CANADA AND UNITED STATES

(as percentages of total chemical production)

Year	1929	1935	1940	1945	1950	1953	1955
Canada							
Industrial	44.1	42.2	52.9	62.3	53.1	56.9	60.0
Consumer	55.9	57.8	47.1	37.7	46.9	43.1	40.0

Year	1929	1939	1947	1953
United States				
Industrial	40.7	49.7	47.2	51.7
Consumer	59.3	50.3	52.8	48.3

SOURCES:—D.B.S. Chemical and Allied Products, Annual. United States—Census of Manufacturers, Dept. of Commerce.

Table 41

CHEMICALS AND ALLIED PRODUCTS INDUSTRIES PROPER, MAJOR SUB-GROUPS, SELECTED YEARS CANADA AND U.S.

(U.S. dollars for United States, Canadian dollars for Canada)

	1929		1939		1947		1953	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Acids, alkalies and salts—No. of plants	220(E)	15	340	25	412	31	n.a.	41
Value added by manufacture $000	141,600(E)	18,800	233,718	14,487	454,699	33,206	1,211,305	70,953
Value of product shipped $000	262,222(E)	28,022	404,027	23,057	881,205	59,318	2,308,282(E)	127,300
Employees—total	22,000(E)	2,897	46,597(E)	3,128	65,347	5,541	109,956	8,278
Employees—wage earners only	15,500(E)	2,517	33,593	2,406	50,203	4,636	81,759	5,834
Fertilizers—No. of plants	638	12	763	27	704	31	n.a.	40
Value added by manufacture $000	72,710	791	57,241	4,319	186,601	28,902	284,131	43,094
Value of products shipped $000	232,511	2,259	185,990	13,165	504,505	58,784	993,370(E)	84,354
Employees—total	24,977	251	24,167(E)	1,211	31,933	3,258	34,789	3,199
Employees—wage earners only	20,926	204	18,807	857	26,574	2,667	26,655	2,239
Medicinals and Pharmaceuticals—No. of plants	1,392	140	1,117	174	1,355	213	n.a.	217
Value added by manufacture $000	268,444	12,628	260,649	17,180	748,570	43,501	1,306,435	62,019
Value of products shipped $000	386,629	19,039	386,357	27,184	1,198,625	70,291	2,094,215(E)	93,557
Employees—total	35,460	2,849	43,678(E)	4,388	81,803	7,678	94,026	7,492
Employees—wage earners only	24,518	1,835	24,212	2,479	54,725	5,260	58,897	4,395
Paints and varnishes—No. of plants	1,063	69	1,225	93	1,456	109	n.a.	122
Value added by manufacture $000	234,844	14,337	225,818	13,443	573,237	31,063	815,654	57,348
Value of products shipped $000	568,976	27,103	510,192	25,856	1,537,602	69,912	2,030,160(E)	113,248
Employees—total	42,099	2,851	45,335(E)	3,540	67,807	5,428	74,601	5,887
Employees—wage earners only	29,211	1,942	27,660	1,971	45,822	3,520	44,470	3,428
Soaps, washing and cleaning compounds—								
No. of plants	881	61	986	110	1,392	166	n.a.	141
Value added by manufacture $000	177,556	7,946	200,988	10,597	606,079	23,491	782,274	49,732
Value of products shipped $000	385,653	19,219	410,164	20,145	1,398,860	53,200	1,706,780(E)	89,249
Employees—total	25,771	1,854	31,390(E)	2,406	44,962	3,262	47,437	3,824
Employees—wage earners only	18,693	1,206	19,509	1,465	29,729	2,060	28,194	2,166

Table 41 (cont'd)

	1929		1939		1947		1953	
	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Toilet preparations—No. of plants	815	49	539	86	718	100	n.a.	94
Value added by manufacture $000	135,142	2,860	88,956	4,099	226,872	10,182	381,536	19,007
Value of products shipped $000	193,441	4,452	147,466	6,919	371,892	16,888	575,042	30,438
Employees—total	19,229	577	15,614	1,135	26,023	1,870	23,128	1,955
Employees—wage earners only	13,109	373	10,363	671	18,186	1,232	15,276	1,284
Vegetable oil mills—No. of plants	582	8	557	9	549	15	n.a.	13
Value added by manufacture $000	77,822	860	57,461	995	329,656	5,271	323,200	6,359
Value of products shipped $000	409,702	6,503	302,657	4,157	1,630,204	38,348	1,615,889	50,843
Employees—total	21,952	239	23,846(E)	239	27,471	746	25,000	675
Employees—wage earners only	18,540	203	19,652	185	22,853	598	21,000	444
Primary plastics—No. of plants	10(E)	n.a.	41	n.a.	125	10	n.a.	19
Value added by manufacture $000	19,050(E)	n.a.	39,742	n.a.	200,341	6,403	562,854	19,139
Value of products shipped $000	40,531(E)	n.a.	83,324	n.a.	483,461	11,783	1,254,502	44,542
Employees—total	5,000(E)	n.a.	10,405(E)	n.a.	29,337	1,060	43,017	2,160
Employees—wage earners only	3,500(E)	n.a.	7,191	n.a.	22,212	789	31,333	1,382
Miscellaneous—No. of plants	3,332(E)	211	2,851	295	2,675	374	n.a.	421
Value added by manufacture $000	577,519(E)	21,424	620,123	31,948	1,871,849	73,902	3,605,956	163,547
Value of products shipped $000	800,153(E)	38,451	1,064,280(E)	53,609	3,617,190	140,310	4,021,048(E)	319,901
Employees—total	176,611(E)	5,415	107,159	10,909	240,525	17,047	301,155	23,121
Employees—wage earners only	156,416(E)	4,051	106,850	8,582	182,224	13,448	217,679	16,580
Total chemicals—No. of plants	8,933	565	8,419	819	9,386	1,049	n.a.	1,108
Value added by manufacture $000	1,704,687	79,646	1,784,696	97,068	5,197,894	255,921	9,273,345	491,198
Value of products shipped $000	3,279,818	145,048	3,494,457	174,092	11,623,544	518,834	16,599,288(E)	953,432
Employees—total	373,099	16,933	348,191(E)	26,956	615,208	45,890	753,109	56,591
Employees—wage earners only	300,413	12,331	267,839	18,616	452,528	34,210	525,263	37,752

(E)—Estimated

SOURCE: U.S. Census of Manufactures Dept. of Commerce; and Canadian Census of Industry, D.B.S.

Table 42

CHEMICALS AND ALLIED PRODUCTS INDUSTRIES PROPER, MAJOR SUB-GROUPS, SELECTED YEARS CANADA AND UNITED STATES[a]

(U.S. dollars for United States, Canadian dollars for Canada)

Major sub-groups	Year	Size of establishments: Value added per plant		Size of establishments: Production workers per plant		Productivity average value added per employee		Rate of growth net value of production (ratios)			Net value of production U.S. multiple of Canada
		U.S. ($000)	Canada ($000)	U.S. (numbers)	Canada (numbers)	U.S. ($000)	Canada ($000)		U.S.	Canada	
Acids, alkalies and salts	1929	644	1,253	70	168	9.1	7.5	—	—	—	8
	1939	687	579	99	96	6.9	6.0	1939/29	1.65	.77	16
	1947	1,104	1,071	122	150	9.1	7.2	1947/39	1.95	2.29	14
	1953	n.a.	1,731	n.a.	142	14.8	12.2	1953/47	2.66	2.14	17
Fertilizers	1929	114	66	33	17	3.5	3.9	—	—	—	92
	1939	75	160	25	32	3.0	5.0	1939/29	.79	5.46	13
	1947	265	932	38	86	7.0	10.8	1947/39	3.26	6.69	6
	1953	n.a.	1,077	n.a.	56	10.7	19.2	1953/47	1.52	1.49	7
Medicinals and pharmaceuticals	1929	193	90	18	13	10.9	6.9	—	—	—	21
	1939	233	99	22	14	10.8	6.9	1939/29	.97	1.36	15
	1947	552	204	40	25	13.7	8.3	1947/39	2.87	2.53	17
	1953	n.a.	286	n.a.	20	22.2	14.1	1953/47	1.75	1.43	21
Paints and varnishes	1929	221	208	27	28	8.0	7.4	—	—	—	16
	1939	184	144	23	21	8.2	6.8	1939/29	.96	.94	17
	1947	394	285	31	32	12.5	8.8	1947/39	2.54	2.31	18
	1953	n.a.	470	n.a.	28	18.3	16.7	1953/47	1.42	1.85	14
Soaps, washing and cleaning compounds	1929	202	130	21	20	9.5	6.6	—	—	—	22
	1939	204	96	20	13	10.3	7.2	1939/29	1.13	1.33	19
	1947	435	142	21	13	20.4	11.4	1947/39	3.02	2.22	26
	1953	n.a.	353	n.a.	15	27.7	23.0	1953/47	1.29	2.12	16

Table 42 (cont'd)

Major sub-groups	Year	Size of establishments: Value added per plant U.S. ($000)	Value added per plant Canada ($000)	Production workers per plant U.S. (numbers)	Production workers per plant Canada (numbers)	Productivity average value added per employee U.S. ($000)	Productivity Canada ($000)	Rate of growth net value of production (ratios)	U.S.	Canada	Net value of production U.S. multiple of Canada
Toilet preparations	1929	166	58	16	8	10.3	7.7	—	—	—	47
	1939	165	48	19	8	8.6	6.1	1939/29	.66	1.43	22
	1947	316	102	25	12	12.5	8.3	1947/39	2.55	2.48	22
	1953	n.a.	202	n.a.	14	25.0	14.8	1953/47	1.68	1.87	20
Vegetable oils	1929	134	108	32	25	4.2	4.2	—	—	—	90
	1939	103	111	35	20	2.9	5.4	1939/29	.74	1.16	58
	1947	600	351	42	40	14.4	8.8	1947/39	5.74	5.30	63
	1953	n.a.	489	n.a.	34	15.4	14.3	1953/47	.98	1.21	51
Primary plastics	1929	1,905	—	350	—	5.4	—	—	—	—	—
	1939	969	—	175	—	5.5	—	1939/29	2.09	—	—
	1947	1,603	640	178	79	9.0	8.1	1947/39	5.04	—	31
	1953	n.a.	1,007	n.a.	73	18.0	13.8	1953/47	2.81	2.99	29
Miscellaneous	1929	173	102	47	19	3.7	5.3	—	—	—	27
	1939	218	108	37	29	5.8	3.7	1939/29	1.07	1.49	19
	1947	699	198	68	36	10.3	5.5	1947/39	3.02	2.31	25
	1953	n.a.	388	n.a.	39	16.6	9.9	1953/47	1.93	2.21	22

[a]Data for U.S. from U.S. Census of Manufacturing Industries, Department of Commerce; for Canada from Census of Industry, D.B.S. In some cases where comparable U.S. data were not available, estimates were prepared. Numbers of Plants data were not available for the U.S. in 1953.

Table 43

PRINCIPAL STATISTICS FOR THE CHEMICAL PROCESS INDUSTRIES, CANADA, 1954

Industry	Establishments	Employees	Earnings	Cost of fuel and electricity at plant	Cost of materials at plant	Value of factory shipments
	No.	No.	(000's of dollars)			
Pulp and paper	125	60,837	252,598	84,891	515,258	1,241,558
Sugar refining	11	3,426	11,353	2,501	81,010	117,807
Distilled liquors	21	5,049	16,111	2,212	45,250	125,967
Wineries	20	484	1,781	130	4,680	12,045
Breweries	62	8,541	33,423	2,651	47,590	198,390
Rubber goods	73	20,894	67,476	4,000	106,502	264,185
Dyeing of textiles	53	1,940	5,403	735	3,030	11,632
Leather tanning	55	3,798	10,903	1,038	23,532	42,609
Coke and gas	26	4,759	16,297	6,036	54,020	104,927
Artificial abrasives	8	2,044	7,855	3,809	13,260	31,099
Glass	10	5,000	16,661	3,726	15,162	42,285
Petroleum refining	40	12,048	50,797	30,973	558,856	890,997
Non-ferrous metal smelting and refining	22	26,048	102,596	55,225	515,316	922.579
Total process industries	526	154,868	593,254	197,927	1,983,466	4,006,080

SOURCE: Census of Industry, D.B.S.

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[1]This is one of a series of three studies on Canadian international economic relations prepared under the direction of S. S. Reisman.

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